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GENERALIZED INTERSTITIAL EMPHYSEMA AND SPONTANEOUS PNEUMOTHORAX

AS COMPLICATIONS OF BRONCHOPNEUMONIA

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In the recent epidemic of influenza and bronchopneumonia at Camp Lewis, extensive subcutaneous and interstitial emphysema has occurred in nine patients as a complication of bronchopneumonia. The clinical picture of this emphysema, extending up over the neck, face and scalp, and down over the chest and trunk to the pelvis, and even to the external genitalia, is of such rarity and interest that the cases are here reported. Spontaneous pneumothorax has developed in two patients having extensive bronchopneumonia. That there is a relationship between these two conditions and that they are produced by similar pathologic processes has seemed likely. One case, in fact, presented, at different times, both of these complications. In this paper we are presenting an explanation of the mechanics of these unusual complications.

In each instance, the diagnosis of our cases of bronchopneumonia has been corroborated by roentgenography, and, in fatal cases, by necropsy. Early in the epidemic it was recognized that the type of pneumonia with which we were dealing was not the type that is usually found in vigorous young adults, characterized by an acute onset with a chill followed by fever and rapid respiration. The clinical picture has, however, been one of a fairly set type. The usual onset is with general malaise over a period of from twenty-four to forty-eight hours, more or less diffuse body pains, aching joints, cough and chilliness. On admission, as a rule, the patients appeared only moderately ill. The initial temperature was rarely over 101 F. The phys-

ical signs in the lungs were often scant, so much so in some cases that they were recognized as definite pneumonias by the ward surgeons only after they had been in the hospital for from twenty-four to forty-eight hours. At this time definite lung findings were usually present, such as impaired resonance or dullness over the affected part, with either harsh or diminished breath sounds and, on inspiration, showers of fine, moist râles. A discussion of the physical signs and the diagnosis of the type of pneumonia occurring in this epidemic will be given in a subsequent paper.

After three or four days in the hospital, the greater proportion of the patients showed a marked improvement and went on to an uninterrupted recovery. In the other cases at the same time there was a tremendous extension of the process, and the condition at once became critical.

It was among the latter group that the occurrence of interstitial emphysema and spontaneous pneumothorax were noted.

That our cases of pneumonia have been milder than the cases in other camps is evidenced by our mortality rate, which, at the present writing, is 9.22 per cent., or 157 deaths.

LUNG INVOLVEMENT

The patients developing emphysema or pneumothorax, for the most part, had extensive lung involvement as is shown by Table 1.

In Table 2 is shown the extent of the emphysema, together with the promi-

nent symptoms that were apparently associated with its development. The severity of the paroxysms of cough in these cases was well demonstrated by the occurrence in one case of a rupture of the rectus muscles, and in several other cases by definite hemorrhages into these muscles. A sudden severe paroxysm of cough with pain in the chest and the spitting up of frothy, bloody sputum seemed in several cases to mark the onset of the emphysema.

Two other cases of emphysema occurred that have not been included in Table 2. One of these presented emphysema as a complication after a thoracotomy for empyema, and the other showed an emphysema following pneumothorax and thoracotomy. In both of these cases there was an extensive bronchopneumonia of the

Fig. 1.—Chest in extreme generalized emphysema. Bronchopneumonia of entire right lung. Note lack of pulmonary detail due to air in subcutaneous tissues. Marked air dissection in both axillae.

lung on the unoperated as well as on the operated side. The development of the emphysema in both of these cases, though following operation, was precisely similar to the development of the emphysema in our other cases. That there was probably no direct relation between the operation, per se, and the development of the emphysema will be pointed out later.

Fig. 2.—Extensive dissection of subcutaneous tissue and muscle sheaths, typical of emphysema.

BACTERIOLOGIC FINDINGS

It has been a routine in this hospital to obtain sputum cultures in all cases of pneumonia when satisfactory specimens could be obtained. Also, in case of death, cultures are taken at the time of necropsy. It has not been possible to establish any relationship between the causal organism in a case of pneumonia and the development of emphysema or pneumothorax. In Table 3 are given the bacteriologic findings in the cases reported.

ONSET AND EXTENSION OF SUBCUTANEOUS AND INTERSTITIAL EMPHYSEMA

Without exception the emphysema was first noted in the soft tissues at the episternal notch or above one or both clavicles, spreading from these points to the neck, face, scalp, chest, arms and trunk.

That this was a true subcutaneous and interstitial emphysema and not a gas bacillus infection was at once established by the absence of inflammation, by the clinical progress and by roentgenograms. In gas

TABLE 1.—LUNG INVOLVEMENT IN CASES IN WHICH EMPHYSEMA OR PNEUMOTHORAX DEVELOPED

Case No.	Lobes Involved					Complication
	R. U.	R. M.	R. L.	L. U.	L. L.	
25540	+	+	+	0	+	Emphysema
27201	+	0	0	+	+	Emphysema
27365	+	+	+	+	+	Emphysema
27975	+	+	+	+	+	Emphysema
28670	+	+	+	+	+	Emphysema
29129	+	+	+	+	+	Emphysema
29292	+	+	+	+	+	Emphysema
29940	0	0	+	0	+	Emphysema.
31158	+	+	+	+	+	Emphysema
24932	+	+	+	+	0	Pneumothorax
30274	T. B.	0	+	T. B.	+	Pneumothorax and emphysema

bacillus infection it has been clearly demonstrated by roentgenoscopy that the gas is diffusely distributed throughout the entirety of the involved tissues, whereas in emphysema the air is found to dissect its way along blood vessel and muscle sheaths in the line of least resistance. In Figures 1 and 2 are shown reproductions of the roentgenographic findings.

It is interesting to note that, with this extensive dissection, the patients complained of very little pain and little or no tenderness over the emphysematous areas. All patients did, however, complain of choking sensations.

MECHANISM OF THE PRODUCTION OF EMPHYSEMA AND PNEUMOTHORAX

It is of considerable interest to know just how the emphysema and pneumothorax are produced. It seems probable, as both conditions were found in the same patient at different times, that the same factors that produce one may produce the other.

TABLE 2.—EXTENT OF EMPHYSEMA, WITH PROMINENT SYMPTOMS

Case No.	Extent of Emphysematous Involvement										Symptoms at Onset	Outcome of Case
	Supraclavicular Space	Intraclavicular Space	Neck	Face	Scalp	Arms	Chest	Trunk	Genitalia	Thighs		
25540	+	+	+	+	+	+	+	+	+	+	Severe cough; bloody sputum	Recovery
27365	+	+	+	+	0	+	+	+	0	0	Choking; sharp pain in chest	Death
27975	+	+	+	+	0	0	0	0	0	0	No notes	Death
28670	+	+	0	0	0	0	+	0	0	0	Severe cough; bloody sputum	Recovery
29129	+	0	+	0	0	0	0	0	0	0	No notes	Death
29292	+	+	+	+	+	+	+	+	+	0	No notes	Death
29940	+	+	+	0	0	0	+	0	0	0	Severe cough; bloody sputum	Recovery
31158	+	+	+	0	0	0	+	0	0	0	Sharp pain	Death

In passing from the lungs to the chest wall the air may follow one of two routes, which may be termed (1) the intrapleural route and (2) the extrapleural route.

1. *The Intrapleural Route.*—For air to pass from the lungs to the chest wall by this route, it must pass through both the visceral and the parietal pleura. To pass through both the visceral and parietal pleura

Fig. 3.—Extensive emphysematous excavations (light areas) in lungs. Plate taken under ray filter to eliminate high lights.

without producing a pneumothorax it must be assumed that adhesions between these membranes exist at some area and that the passage of air occurs at this point. At necropsy this seemed the possible route in but one case (27201). In this case air could be easily forced out of the lung at a point where recent adhesions had

formed and where the parietal pleura at the corresponding point was found to be lifted up by air. It was apparently possible, in this case, to demonstrate

Fig. 4.—Roentgenogram of excised lung, showing well-marked emphysematous excavations especially along the lung periphery. Note especially the collapsed upper lobe and the central consolidation of lower lobe.

that a direct passage of air occurred in this manner. We are of the belief, however, that this is rarely the route taken.

2. *Extrapleural Route*.—For air to gain access to the mediastinum from the lung without passing through

TABLE 3.—BACTERIOLOGIC FINDINGS IN CASES REPORTED

Case No.	Type of Pneumococcus	Type of Streptococcus	B. Influenzae	Tubercle Bacillus
25540	IV	0	+	0
27201	0	Nonhemolytic	0	0
27365	IV	Nonhemolytic	+	0
27975	IV	Nonhemolytic	0	0
28670	IV	Nonhemolytic	0	0
29129	IV	Nonhemolytic	+	0
29292	0	Nonhemolytic	0	0
29940	IV	Nonhemolytic	0	0
31158	IV	Nonhemolytic	0	0
24932	IV	0	0	0
30274	IV	0	0	+

the pleura, it would be necessary to assume a rupture of an air sac and a dissection of air from this sac back to the hilum.

Ruptured air sacs in the peripheral borders of the lung have been found frequently at necropsy. In many cases numerous adjacent air sacs have ruptured, forming a large air space, aptly termed "emphysematous excavations" by our roentgenographer, Capt. F. E. Diemer. On removal of the lungs, these excavated areas were found to be distended and covered by tense pleura. Leading off from these excavations were "air

streaks" (a term suggested by Capt. M. C. Terry), definitely following the course of blood vessels. Air could be readily forced from the air spaces to the air streaks.

Dissection of the lung also showed that these air streaks could be traced along the course of blood vessels to the hilum. Also, by exposing the hilum of the lung extrapleurally without rupturing the bronchus, and submerging it in water, it was possible, by gently squeezing the lung, to force bubbles of air out at the hilum, the bubbles rising from around the blood vessel walls. This was accomplished through the mediastinum, with the lungs still in place in the chest cavity. Thus it is seen that, with a valvelike entrance from a bronchiole into an air space, a continual flow of air will be produced from the parenchyma of the lung to the soft tissues of the posterior mediastinum. From the posterior mediastinum the air dissects its way to the superior mediastinum, and enters the subcutaneous tissues of the neck and axilla by following the blood vessel sheaths through the deep fascia.

Many cases that did not show a pneumothorax or an emphysema of the chest wall were found at necropsy to have numerous excavations of varying size. They were so extensive in some instances that the lingula or the entire anterior margin of the lobes appeared to be blown up with air. A photograph of one of these lungs is reproduced in Figure 3. Also, by taking roentgenograms of the lung after removal it was possible to show these areas fairly well. A reproduction

Fig. 5.—Roentgenogram of an excised lung, showing a true pulmonary emphysema without emphysematous excavations. Compare with Figure 4.

of one of these plates is given in Figure 4. This is contrasted in Figure 5 with a similar roentgenogram of an ordinary emphysematous lung.

It was also possible, by roentgenograms, to show excavated areas in certain of the more marked cases during the life of the patient (Fig. 6). The future of these patients, showing emphysematous excavations, who eventually recovered from their pneumonic infection, presents an interesting problem. One patient,

Fig. 6.—Roentgenogram in a case of bronchopneumonia (resolved, both bases), showing an emphysematous streak along the course of a blood vessel in midportion of right lung field.

now quite convalescent, still shows these areas by roentgenoscopy. Whether they will eventually contract down and close by scar tissue formation, or will develop into bronchiectatic cavities, only time will tell.

PNEUMOTHORAX

As stated above, it seemed likely that the same process that resulted in emphysema in one case might in another result in a pneumothorax. With the formation of the emphysematous excavations on the peripheral border of the lungs, the pleural covering was

Fig. 7.—Roentgenogram in case of pneumothorax after thoracotomy for relief of pressure. By fluoroscopy prior to thoracotomy the right lung was markedly compressed and the heart pushed to the left. The lung is in the position of collapse and the heart is not displaced.

lifted and put under considerable tension. From these points the dissection of air toward the hilum took place. In paroxysms of coughing the pressure within this space was, of course, considerably increased. Any obstruction to the dissection of this air along the vessel

sheaths, or an increase in pressure that exceeded the rate of outlet by dissection, would result in a rupture of the pleural covering of this air space, and a pneumothorax would result. This condition occurred in two of our cases. The roentgenograms of these cases are given in Figures 7 and 8. The pressure fluid present in both of these cases may possibly have been the reason for the delayed escape of air from the air spaces by dissection along the vessel sheaths. In Case 30274, however, tuberculosis must be borne in mind as a possible cause for the pneumothorax.

The symptoms in the two cases of pneumothorax varied widely. Patient 24932, coughed frothy, bloody sputum for three or four days, but showed little or no discomfort, while Patient 30274 was extremely dyspneic. To relieve this dyspnea a thoracotomy was done. Stereoscopic examination in this case prior to thoracotomy showed the right lung to be markedly compressed and the heart forced markedly to the left. After thoracotomy the lung expanded to the position of collapse and the heart returned to its normal posi-

Fig. 8.—Pyopneumothorax. Exposure made with patient in prone, postero-anterior position. The decrease in radiability over the pneumothorax is due to the fluid present. The right upper lobe is not collapsed, owing to the well-marked pleural adhesions. Note the heart displacement and lung compression due to pressure of the pneumothorax.

tion (Fig. 7). Six hours after the thoracotomy a well-marked emphysema was found in the suprasternal notch and above the clavicle on the right side, although careful search revealed no emphysema around the operative wound. It is believed that the marked pressure of the pneumothorax on the hilum prevented the exit of air from the hilum of the left lung, and that the release of this pressure by thoracotomy allowed its escape into the mediastinum with the resultant emphysema.

A similar explanation is offered for the development of the emphysema, postoperatively, in Case 27201 (Fig. 9). It is assumed that the fluid in the left chest caused a compression of the hilum, thus preventing the escape of air until thoracotomy had been done. The emphysema first developed on the side opposite to the operative wound, and no emphysema was noted about the wound. It was on the unoperated side in this case that it was apparently possible to show the direct passage of air through pleural adhesions to the chest wall.

COMMENT

The rarity of the two unusual complications of bronchopneumonia described in the foregoing is

Fig. 9.—Extensive emphysema developing after thoracotomy for empyema. Note equal air dissection in both axillae. Clinically the emphysema was first noted above the right clavicle (operation on left side). No emphysema around operative wound. Pneumonic process not visible, owing to the marked emphysema.

emphasized by their occurrence in only eleven out of 1,701 cases of bronchopneumonia seen at this hospital during the recent epidemic.

PREVENTION OF RELAPSES IN CASES OF ARRESTED TUBERCULOSIS AMONG SOLDIERS*

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Relapses from tuberculosis in the civilian population, particularly among the working classes, present a most difficult medical and economic problem; but when we are dealing with soldiers and sailors, that is to say, young men between the ages of 20 and 36, representing the flower of the manhood of the nation, it becomes all the more serious. In my address on "Blinded Soldiers as Masseurs," read before the Conference on Rehabilitation of the Wounded in Philadelphia, Sept. 20, 1918, I¹ endeavored to throw out some suggestions as to the possible solution of the study of the various phases involved and a description of some therapeutic methods whereby it is hoped to reduce the number of relapses among tuberculous soldiers and sailors and, if possible, to shorten the time necessary to attain a reasonable security against any recurrence of the old trouble, thus aiding an early and permanent rehabilitation.

* This article is abbreviated for publication in THE JOURNAL by the omission of some literary references. The complete article will appear in the author's reprints.

* Read before the North Atlantic Tuberculosis Conference, Pittsburgh, Dec. 7, 1918; before the Clinical Society of the New York Post-Graduate School, Jan. 17, 1919, and before the Section on Medicine of the New York Academy of Medicine, Feb. 18, 1919.

1. Knopf, S. A.: Med. Rec. 94: 709 (Oct. 26) 1918.

Not only we so-called tuberculosis specialists, consultants or sanatorium physicians in civil practice, but also that splendid corps of men and women who are our collaborators in solving the social problems of tuberculosis, know of the frequency of relapses among those who are sent home from the sanatoriums or health resorts as arrested or apparently arrested cases. However, it is not the fault of the sanatorium physicians or practitioners in climatic health resorts that in many cases which have been discharged as arrested, relapse occurs sooner or later and sometimes after relatively short periods. The vast majority of our tuberculous patients leave our sanatoriums and resorts too soon because of economic necessity and their eagerness to return home in order to make a living for themselves or their dependents. I am sure that if it were in the power of the sanatorium authorities or practitioners in the health resorts to retain them longer, many relapses would be avoided.

The patients that are discharged or discharge themselves as arrested or nearly arrested cases, are not considered even "apparent" cures. The definition of the term "apparent cure" is that all constitutional symptoms and expectoration with bacilli shall have been absent for a period of at least two years under ordinary conditions of life. An arrested case is one in which all constitutional symptoms, expectoration and the bacilli have been absent for a period of six months, and the physical signs are those of a healed lesion. An apparently arrested case is one in which all constitutional symptoms and expectoration with bacilli have been absent for three months, the physical signs being those of a healed lesion.

For a long time I have asked myself, What can and should be done in order to shorten the period between

Fig. 1.—Original position.

Fig. 2 (first exercise).—Raising the shoulders.

the time when a case is arrested and when it can be considered cured? I have already absolved the sanatorium and health resort physicians from blame, but there is no denying the fact that a great number of patients return home, with the label "arrested case," whose muscles are flabby from the prolonged rest-cure on the