THE DIAGNOSIS OF "EVENTRATION" OF THE DIAPHRAGM

WITH REPORT OF A CASE OF APLASIA OF THE RIGHT LUNG
AND RIGHT HALF OF THE DIAPHRAGM, ASSOCIATED
WITH CONGENITAL DEXTROCARDIA *

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I. INTRODUCTION

So-called "eventration" of the diaphragm is understood to mean a high position of one-half of the phrenic leaf, conditioned, not simply on displacement, but on aplasia (congenital) or atrophy (acquired) of the muscle fibers of that half of the diaphragm. Obviously, the term is a misnomer, but it appears that the various terms which have been offered as substitutes, while in themselves more exact, have served by their multiplicity merely to add to the confusion in terminology. One is tempted to choose from among these terms one more suitable, but inasmuch as the condition is definitely defined, it may as well go by the name of "eventration" as by any other.

I propose in this paper (1) to make a critical review of the literature on eventration of the diaphragm principally from the standpoint of the diagnosis, attempting also to establish or disprove the authenticity of the reported cases, and (2) to lay emphasis on the necessity for a careful study of the respiratory excursion of the thorax in the endeavor to differentiate eventration of the diaphragm from the condition with which it has been invariably confounded—hernia of the diaphragm, and (3) to present two cases illustrative of the points of differentiation.

2. REVIEW OF THE LITERATURE

If one undertakes a careful search of original sources in this subject, he soon discovers many errors which have crept into subsequent writings, there to be perpetuated and magnified. Some of these I shall attempt to correct.

The first authentic case of eventration of which we have record is that of Jean Louis Petit,¹ the description appearing originally in his posthumous "*Traite des maladies chirurgicales, etc.*" the first edition of which, edited by Lesne, was published in 1774. Petit himself, however, does not in any part of his writings employ the term "eventration," but describes his case as a peculiar variety of diaphragmatic hernia.

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1. Petit: *Traite des maladies chirurgicales*. Paris 2:266, 1774.

It was not until the time of Cruveilhier² that the essential difference between hernia and eventration was elucidated. The credit for the introduction of the term "eventration" has been distributed variously. Part of this confusion is, no doubt, due to the fact that Cruveilhier directly contradicted himself in this connection. In the *Anatomie pathologique du corps humain* (1829), he states unequivocally that Petit's case had been shown by Béclard to belong more properly in the class of eventrations. Twenty years later, in his *Traité d'Anatomie pathologique generale*, he says it was Petit who gave the name of "eventration." Inasmuch as no reference to the term is to be found in Petit's original writings, one is inclined to accept Cruveilhier's original statement, crediting Béclard with being the first to make use of the term in critical differentiation of the condition from hernia of the diaphragm. In this connection it should be stated that Cruveilhier's first recorded reference to the condition of eventration, according to Betchov,³ occurred in 1816. Petit's description of his case is very convincing. Clinically, the patient

"had been for a long time afflicted with a so-called asthma, which to all appearances had no other cause than the hernia, inasmuch as he felt himself relieved of the so-called asthma as soon as he had eaten."

The patient having died of peritonitis, Petit says of the necropsy:

As those who believed him asthmatic had mistaken the peritonitis for a pleural effusion, I commenced the section with the chest, where I found nothing but a little fluid, with a tumor the size of a small gourd. The tumor . . . was almost as large at the base as at the middle, and terminated in a blunt cone, having a height of 3 or 4 inches"

Section of the abdomen revealed the peritonitis, and

"the parts contained in the hernia were all stuck together and adherent to the sac. As for the sac, . . . I discovered that it was nothing but a prolongation of the peritoneum, the diaphragm, and the pleura, together, without the slightest rupture of the membranes, or any opening in the muscular or tendinous fibers of the diaphragm."

Previous to Petit's case, there is but one which might be called into question. It is that of Senac (1729), considered by Bowditch⁴ in 1853 to have been in all probability a genuine instance of eventration. Reference to Senac's original article⁵ discloses what was more probably a case of right-sided interstitial pneumonitis and chronic fibrous pleurisy, with fixation of the diaphragm in a high position by pleural retraction and synechia. There is no definite statement about the condition of the pleura, the pleural sinus, or the musculature of the diaphragm.

2. Cruveilhier: *Anatomie pathologique du corps humain*, Paris, 1829, Tome I, Livr. XVII; *Traité d'Anatomie pathologique générale*, Paris, 1849, Tome I, pp. 614 and 617.

3. Betchov: *Rev. méd. de la Suisse Rom.*, **37**:455, 1917.

4. Bowditch: *Buffalo M. J.*, **9**:1, 65, 1853.

5. Senac: *Sur le diaphragme*. (From *Mem. Acad. roy. d. sc. de Par.*, 1729.) *Collect. Acad. d. Mem., etc.*, Par. **6**:440, 1781.

In 1783, Pyl⁶ described a case, which, according to Lacher,⁷ showed the left side of the diaphragm to be attenuated and dilated like a hernial sac. Glässner,⁸ and many others, have likewise been convinced of the genuine nature of this case. Access to the original article was denied me, but in view of Lacher's misconception of the cases of Froriep and Meckel one cannot but be somewhat skeptical of his interpretation.

It is when one comes to the consideration of the cases described by Meckel and Froriep that the more conspicuous instances of perpetuation of error appear. These cases have been generally accredited as true examples of eventration since they were first so labelled by Lacher in 1880. To quote from Lacher directly,

In Kleinert's Repertorium, 1837, a case of Froriep's is cited, in which, at the necropsy of a 19 year old girl who had complained constantly of shortness of breath, vomiting and other gastro-intestinal disturbances, and since her fourteenth year had been troubled with obstinate constipation, the left diaphragm was found to be an upward-projecting sac containing the stomach, displacing the heart considerably to the right; the diaphragm was abnormally thin and in the region of the mediastinum changed to a transparent cellular tissue. This abnormal thinning out seemed to be definitely congenital, for no other cause, as for instance, inflammation of the diaphragm or diaphragmatic pleura, was mentioned.

A careful search of all four volumes of the Repertorium for 1837 reveals but one reference to such a condition by Froriep,⁹ which is herewith set down verbatim:

A diaphragmatic hernia, where the stomach lay in the left half of the chest, pushing the heart toward the right, was found in the corpse of a girl of 19 years, who from childhood had suffered from dyspnea, vomiting and other gastro-intestinal disturbances.

The identity of the two subjects seems quite clear, but the disparity in the reports is too obvious to pass unchallenged.

Of Meckel's case, Lacher says that on the left side the diaphragm was arched out like a sac. The description of this case in Zwanziger's original article¹⁰ (1819) is as follows:

A mature feminine fetus. The left pleural sac contains, besides the normal: (1) the stomach, with (2) the small intestine, except the duodenum, (3) the greater part of the colon, (4) the spleen. The parts are thus arranged: The esophagus, descending in the usual manner to the vicinity of the diaphragm, is turned a little bit upward and enters the stomach. The stomach is turned in a

6. Pyl: Aufsätze u. Beobacht. a. d. ges. Med., Ser. 5, p. 29, 1783.

7. Lacher: Deutsch. Arch. f. klin. Med. **27**:268, 1880.

8. Glässner: Fortschr. a. d. Geb. d. Röntgenstr. **24**:268, 1916; München. med. Wchnschr. **63**:19, 1916.

9. Froriep: Kleinert's Allg. Repertorium der gesammten deutsch. med.-chir. Journalistik, Leipzig, N. S. **1**:53 (Oct.-Dec.) 1837.

10. Meckel: Cited by Zwanziger, Dissertatio inauguralis medico-chirurgica de hernia diaphragmatica. Halae, 1819, p. 26.

great curve a little upward and downward, and is so exceedingly concave that the pylorus almost touches the cardia. The duodenum, by means of a great opening in the left side of the diaphragm, descends into the abdomen and here receives the bile-duct. Making a great curve downward, it returns into the thorax by the same aperture, and passes into the jejunum. This (the jejunum) with the ileum fills almost the whole cavity. The cecum is placed at the top of the left pleural sac. From this the ascending colon descends as far as the diaphragm; then making an obtuse angle, the transverse colon turns backward to the seventh dorsal vertebra. From here the ends of the transverse colon and the descending colon proceed outward (from the pleural cavity) and descend to the external margin of the opening, where they depart into the abdomen. Here everything is as usual. The colon, with looser folds than usual, is affixed to the walls of the thorax. The opening in the diaphragm measures 2 inches. Furthermore, the very little developed left lung measures scarcely an inch in length, and equals scarcely a tenth part of the well developed right lung.

Further comment is unnecessary. Suffice it to say that both Froriep's and Meckel's cases were clear examples of hernia of the diaphragm.

Laennec¹¹ described a case of left-sided eventration in 1819, but his interest is confined to the auscultatory signs. Lawrence's case¹² (1852) was discovered at necropsy. The first case in which there is any note of clinical examination is that of Marsh¹³ (1867) who quotes Paget as follows:

There appeared, notwithstanding this defect (of the diaphragm, discovered postmortem), to be sufficient respiratory power. The patient breathed very forcibly in his dyspnea, and in auscultating him the movements of the chest appeared just as in an ordinary double pneumonia. The stomach was thought to be, as it was found, very high up, but nothing unusual attracted Mr. Archer's or my attention; the left side of the chest certainly moved freely, and the patient often lay on his right side.

That the side which was the seat of the eventration "certainly moved freely" was apparently contrary to the expectations of the examiners. The reports by Tennant¹⁴ (1894) and Thomä¹⁵ (1882) deal purely with the pathologic findings in genuine cases of eventration. Crispino's case, according to Sailer and Rhein,¹⁶ was doubtless one of eventration. The original article was not accessible.

The case of Struppler,¹⁷ described in 1901, is of some interest. Struppler himself, with the aid of the roentgen ray, made a diagnosis of hernia of the diaphragm. His arguments in favor of this diagnosis, however, are far from convincing, and his published skiagrams appear to show clearly an abnormally high, but intact, left diaphragm. One of them depicts a stomach tube, filled with mercury, lying in the

11. Laennec: *L'Auscultation Mediate*, Paris **1**:429, 1819.

12. Lawrence: *Lancet* **2**:327, 1852.

13. Marsh: *Lancet* **1**:298, 1867.

14. Tennant: *Edinburgh M. J.* **40**:29 (July) 1894.

15. Thomä: *Virchow's Arch. f. path. Anat.* **88**:515, 1882.

16. Sailer and Rhein: *Am. J. M. Sc.* **129**:688, 1905; Crispino: Cited by Sailer and Rhein.

17. Struppler: *Deutsch. Arch. f. klin. Med.* **70**:1, 1901.

stomach beneath the diaphragm. One is inclined to consider this case as an example of eventration, as have Arnsperger,¹⁸ Bayne-Jones,¹⁹ Glässner, and others. The case is the first to be studied with the roentgen ray, and it is immediately apparent that this procedure is so far from being a diagnostic aid in the differentiation of hernia from eventration that it precipitates a polemic which has raged unabated ever since.

From the article of Neisser²⁰ (1901) one might conclude that he had really observed cases of eventration of the diaphragm, associated, possibly, with aplasia of the lung, but his description suggests much and establishes little. The case described first by Widenmann²¹ in 1901, later also by Glaser²² and Fraenkel,²³ with pathologic findings by Benda,²⁴ was a classical one. Widenmann did not definitely decide the question between hernia and eventration, and Glaser and Fraenkel added nothing in their reports. Widenmann observed a difference in the excursion of the two sides of the thorax, there being a very slight impairment in the lower portion on the affected side. To Glaser, the excursion appeared to be symmetrical. The fluoroscope merely added to the confusion. The necropsy findings were characteristic of eventration, the affected half of the diaphragm being the seat of a "lipomatous pseudo-hypertrophy" (Benda). Doering's case²⁵ (1902) seems well substantiated.

The celebrated case of Friedrich Schneider is of interest from several points of view. The first mention of him, according to Neumann,²⁶ occurred in 1890, when he was described by Stinzing as an example of congenital dextrocardia. From that time until his death in 1912 he went about presenting his diagnostic problem to one clinic after another and eventually became the center of a small polemic. He was roentgenographed so diligently that he acquired a burn, from which one infers, as Neumann suggests, that skiagraphy scarcely belongs in the category of diagnostic aids. The next published account of him is by Hirsch,²⁷ in 1900, who made a diagnosis of hernia of the diaphragm on the basis of roentgenographic findings. His skiagrams strongly suggest eventration, but Hirsch does not mention the latter

18. Arnsperger: *Deutsch. Arch. f. klin. Med.* **93**:88, 1908.

19. Bayne-Jones: *Arch. Int. Med.* **17**:221 (Feb.) 1916.

20. Neisser: *Ztschr. f. klin. Med.* **42**:88, 1901.

21. Widenmann: *Berl. klin. Wchnschr.* **38**:279, 1901.

22. Glaser: *Deutsch. Arch. f. klin. Med.* **78**:370, 1903.

23. Fraenkel: *Deutsch. med. Wchnschr., Vereins-Beilage*, No. 48, p. 343, 1902.

24. Benda: Cited by Glaser, *loc. cit.*

25. Doering: *Deutsch. Arch. f. klin. Med.* **72**:407, 1902.

26. Neumann: *Deutsch. med. Wchnschr.* **45**:905; **45**:937, 1919; *München. med. Wchnschr.* **64**:719, 1917.

27. Hirsch: *München. med. Wchnschr.* **47**:996, 1900.

even as a possibility. Glässner states that Schneider's case was described by Volkmann, and that Becker, considering the case as an example of dextrocardia, made it the subject of his inaugural dissertation, Jena, in 1904. Schneider was carefully studied in 1905 by Hildebrand and Hess,²⁸ who were enabled to satisfy themselves of the correctness of their diagnosis of eventration by means of Schlippe's procedure of measuring the respiratory variations in intragastric pressure. The authors take issue with Hirsch over the interpretation of the skiagrams, maintaining that they portray clearly the presence of eventration. A year later, Lotze²⁹ referred to Schneider as a case of diaphragmatic hernia and was promptly rebuked by Hess.³⁰ The last chapter in this little drama was written in 1912 by Von Eggeling,³¹ whose report of the necropsy findings amply substantiated the diagnosis of eventration made by Hildebrand and Hess.

Sailer and Rhein (1905), in reporting a case of eventration, state that the affected half of the diaphragm was moderately thin, but microscopically was found to contain a fair amount of muscular tissue, "which accounted satisfactorily for the respiratory movement," the latter being noted as equal on the two sides. They conclude that, "in eventration of the diaphragm, the respiratory movements are normal." Reference to this will be made again. Wieting's case³² (1906) is notable for two reasons: It was the first example of right-sided eventration, and with it was associated a hernia of the diaphragm. Hamdi, who described this case previously, mentions nothing but the hernia. Wieting goes back over the gross pathology and demonstrates clearly that an eventration also existed, for the entire right phrenic leaf was found to be a "fascia-like structure without muscle fibers," whereas the left diaphragm was found to be normal. It is interesting to note that Glässner, in reporting his own case of right-sided eventration, ignores Wieting.

Cases described in the period from 1907 to 1914 by Herz,³³ Arnspurger, Königler,³⁴ Scholz,³⁵ Franck,³⁶ Appel,³⁷ Becker,³⁸ Scheideman-

28. Hildebrand and Hess: München. med. Wchnschr. **52**:745, 1905.

29. Lotze: Deutsch. med. Wchnschr. **32**:1662, 1906.

30. Hess: Deutsch. med. Wchnschr. **32**:1990, 1906.

31. Von Eggeling: München. med. Wchnschr. **59**:2284, 1912.

32. Wieting: Deutsch. Ztschr. f. Chir. **82**:315, 1906.

33. Herz: Wien. klin. Wchnschr. **20**:1463, 1907.

34. Königler: München. med. Wchnschr. **56**:282, 1909.

35. Scholz: Berl. klin. Wchnschr. **48**:339, 1911.

36. Franck: Beitr. z. klin. Chir. **74**:358, 1911.

37. Appel: Zur Kenntnis der Eventratio Diaphragmatica, Inaugural Dissertation, Greifswald, 1911.

38. Becker: Fortschr. a. d. Geb. d. Röntgenstr. **17**:183, 1911.

del,³⁹ Malkow,⁴⁰ Bergmann,⁴¹ Kayser,⁴² Haase,⁴³ Reuss,⁴⁴ Baetge,⁴⁵ Krause,⁴⁶ and Manges and Wessler⁴⁷ may doubtless be classed with more or less accuracy in the category of eventration. With a few exceptions, the accounts are occupied chiefly with monotonous discussion of contradictory interpretations of roentgenograms. The cases of Beltz⁴⁸ (1910) and Motzfeldt⁴⁹ (1913) rest on necropsy findings. Fischer⁵⁰ (1914) makes mention of a case of eventration which "developed during convalescence from double pneumonia and typhoid fever." The diagnosis was made by a probatory thoracotomy. The inadequacy of his description leaves one in considerable doubt as to the correctness of the diagnosis of eventration.

Kienbock⁵¹ (1914) describes a case in which the diagnosis of eventration was confirmed at the time of an operation for relief of pyloric stenosis. This is probably the same Kienbock^{51a} who seven years previously described a case of diaphragmatic hernia. Apparently, the author never considered it in any other light, yet it has been cited by many as an instance of eventration. It is impossible to decide the question from a perusal of the original description, although the published roentgenogram, half schematic, suggests eventration. In the absence of supporting data, however, the diagnosis of eventration must be met with skepticism.

Glässner (1916) describes two cases as examples of eventration, in one of which the right diaphragm was the part affected. In this connection he ignores Wieting's case entirely, and rejects the right-sided case of Eppinger⁵² (1911) for the reason that it was merely mentioned, not described. Two of Eppinger's three cases were substantiated by necropsy, however, and it is not at all clear that any of them should be discarded. Glässner's case, then, properly becomes the third to be described as an instance of right-sided eventration of the diaphragm.

The five cases reported in 1916 by Weil⁵³ must be regarded with some skepticism in view of the inadequacy of the author's description.

39. Scheidemandel: München. med. Wchnschr. **59**:2168, 1912.

40. Malkow: Cited by Bergmann (loc. cit.).

41. Bergmann: *Ergeb. d. inn. Med. u. Kinderh.* **12**:327, 1913.

42. Kayser: *Fortschr. a. d. Geb. d. Röntgenstr.* **20**:240, 1913.

43. Haase: *Wien. klin. Wchnschr.* **26**:193, 1913.

44. Reuss: *Deutsch. med. Wchnschr.* **39**:743, 1913.

45. Baetge: *Deutsch. Arch. f. klin. Med.* **110**:49, 1913.

46. Krause: *Deutsch. Ztschr. f. Nervenhe.* **47**:328, 1913.

47. Manges and Wessler: *Med. Rec.* **86**:134, 1914.

48. Beltz: *München. med. Wchnschr.* **57**:1006, 1910.

49. Motzfeldt: *Deutsch. med. Wchnschr.* **39**:312, 1913.

50. Fischer: *Med. Rec.* **86**:653, 1914.

51. Kienbock: *Fortschr. a. d. Geb. d. Röntgenstr.* **21**:322, 1914.

51a. Kienbock: *Ztschr. f. klin. Med.* **62**:321, 1907.

52. Eppinger: *Allg. u. spez. Path. d. Zwerchfells*, Suppl. zu Nothnagel's spez. Path. u. Therapie, Wien. u. Leipzig, 1911.

53. Weil: *Vereinig. der Kriegsärztl. beschaff. Aerzte*, Strassburg, Jan. 25, 1916; abstr. in *Deutsch. med. Wchnschr.* **42**:744, 1916.

The cases had previously been "diagnosed" as (1) cardiac enlargement, the precordia extending $7\frac{1}{2}$ cm. to the right of the midsternal line; (2) pulmonary affection; (3 and 4) pleurisy, depending on dulness and enfeebled breath sounds at the base of the left lung; (5) stomach and intestinal disease. All were diagnosed correctly as eventration, according to Weil, by the use of the roentgen ray.

The fourth case of eventration of the right side of the diaphragm was described in 1916 by Bayne-Jones. The diagnosis was made purely from physical examination, although the exact method by which the conclusion was reached does not appear from the author's description of the clinical findings. Roentgenograms and laparotomy confirmed the clinical impression. Wood⁵⁴ (1916) presents a case of eventration diagnosed from the roentgen ray picture. His inaccurate statements concerning the diaphragm and its participation in thoracic excursion betray his ignorance of the subject.

Betchov has written an interesting article (1917) in which he reviews some of the literature and reports a case. He admits frankly his confusion in attempting to establish a diagnosis, which was finally made by Professor Bard purely from the roentgen-ray findings. Betchov refers to a case described in 1917 by Weinberger⁵⁵ as an example of eventration. Weinberger's diagnosis, however, is hernia, and a perusal of his article does not lead to any other opinion. Minowski's case⁵⁶ (1917) is without doubt genuine. Neumann (1919) presents with necropsy findings a classical case of eventration of the diaphragm. His review of the literature is limited to German sources. He states that Lorey, in 1912, presented five cases,⁵⁷ two of which were substantiated by necropsy,⁵⁸ and that more recently Roesch⁵⁹ has described a case. Neither of these reports has been accessible. His discussion of the possible experimental production of eventration, although without the scope of this paper, is very interesting, and one feels inclined, without consulting the references he cites, to agree with him that the complete picture of eventration may well be produced in man by injury to the phrenic nerve.

Reports of cases of eventration by Andree⁶⁰ and Assmann,⁶¹ in 1918, appear plausible. The case of Aronson⁶² (1918) may possibly be considered as an example of right-sided eventration, although the

54. Wood: Surg., Gynec. & Obst. **23**:344, 1916.

55. Weinberger: München. med. Wchnschr. **64**:624, 1917.

56. Minowski: Berl. klin. Wchnschr. **54**:541, 1917.

57. Lorey: Cited by Neumann, Deutsch. med. Wchnschr. **45**:905, 1919.

58. Lorey: Cited by Neumann, Deutsch. med. Wchnschr. **45**:905, 1919.

59. Roesch: Cited by Neumann.

60. Andree: Med. Klin. **14**:990, 1918.

61. Assmann: Fortschr. a. d. Geb. d. Röntgenstr. **26**:1, 1918.

62. Aronson: New York M. j. **108**:196, 1918; Med. Rec. **93**:37, 1918.

author's vague description of the findings raises much doubt. Laparotomy was undertaken for the purpose of resecting a congenital megacolon, but if the diagnosis was confirmed at this time, the report of it is extremely unconvincing. If genuine, it is the fifth case of right-sided eventration of the diaphragm. Schwenke⁶³ (1919) has reported two cases which he believes to be examples of eventration. His description is fairly convincing. Schlecht and Wels⁶⁴ (1920) have published a case of eventration, the diagnosis being confirmed by laparotomy. After the patient recovered from the operation, the authors injected air into his peritoneal cavity for purposes of roentgenographic study. The resulting pictures display the silhouette of the eventrated half of the diaphragm very effectively. They have also produced a pneumoperitoneum "without difficulty" in a patient with hernia of the diaphragm.

Funk and Manges⁶⁵ (1920) reported a case of eventration, the diagnosis being made by the roentgenogram. The patient was sent to the roentgen-ray laboratory with a diagnosis of hydropneumothorax. After seeing the picture, the authors re-examined the patient and discovered that they would have been able to arrive at the correct diagnosis from physical examination alone if they had been careful to observe the movement of the costal margins. Funk⁶⁶ states that there was "distinct widening of the subcostal angle on inspiration, a widening due principally to greater divergence of the left costal border." This is the only case in the literature in which the examiner made any observation of the excursion of the costal margins considered apart from the excursion of the arches of the ribs.

In concluding a critical analysis of the literature, one finds himself unable to make a definite statement as to the number of genuine cases of eventration which have been studied. The criteria by which the diagnosis has been determined are extremely vague and uncertain in a great many cases. A statistical venture on my part results as follows:*

	Left	Right
Cases in which the diagnosis of eventration is regarded as proved.....	18	4
Cases in which the diagnosis of eventration is not proved, but is regarded as reasonably certain.....	41	2
Total	59	6 65

The first group includes, besides the cases substantiated by necropsy or laparotomy in which original articles have been consulted: (1) two cases of Lorey cited by Neumann as having been controlled by

63. Schwenke: *Deutsch. med. Wchnschr.* **45**:1191, 1919.

64. Schlecht and Wels: *Fortschr. a. d. Geb. d. Röntgenstr.* **27**:244, 1920.

65. Funk and Manges: *Med. Rec.* **98**:289, 1920.

66. Funk: *M. Clinics N. America* **4**:1058 (Jan.) 1921.

*See summary of bibliography.

necropsy; (2) the case of Funk and Manges; (3) my case. The reason for the inclusion of the last two is that in both cases the diagnosis was based on some knowledge of the physiology of the intercostal muscles and diaphragm. Statistics compiled by Franck, Motzfeldt, Bergmann, Eppinger, Bayne-Jones, and Neumann, I have shown to be inaccurate. The cases described by Hoffmann⁶⁷ as examples of so-called "rudimentary eventration," and "chronic habitual magenblasse" do not properly belong in the category of true eventration of the diaphragm. The case described by Otten and Schefold,⁶⁸ regarded as eventration by many writers, is also rejected for reasons which will appear later. Fischer's case, although supposed to be substantiated by thoracotomy, is classed as not definitely proved.

In searching for an example of association of eventration of the diaphragm with aplasia of the lung on the affected side, one finds a statement by Glässner to the effect that the coexistence of the two conditions has never been established. Its occurrence is faintly suggested by Neisser and Haase purely on roentgenographic grounds. In the cases coming to necropsy, the state of the lung on the affected side is mentioned only superficially. Motzfeldt makes the statement that in his case the left lung was small and exhibited an anomalous lower lobe—scarcely to be interpreted as aplasia. In this connection, articles by Abercrombie,⁶⁹ Clark,⁷⁰ Kronig,⁷¹ Fitzgerald and Everett,⁷² Ponfick,⁷³ and Barlow⁷⁴ may be consulted, but none of these contains any note of the condition of the musculature of the diaphragm, and none can be considered as an example of eventration. Similarly, the case of Schmit, cited by Baetge and Glässner, cannot be regarded as an instance of true eventration. My case is, I believe, the first in which aplasia of the lung has been shown to accompany the condition of eventration of the diaphragm.

3. THE DIAGNOSIS

Krause said, "Diseases of the diaphragm are proportionately very seldom diagnosed. This is due both to the slight understanding of the physiology of the diaphragm, and the scarcity of the pathological condition." The critic perceives that the second sentence constitutes within itself a fallacy of induction which becomes still greater if he appreciates, not the "slight understanding," but the total want of

67. Hoffmann: München. med. Wchnschr. **54**:112, 1907.

68. Otten and Schefold: Deutsch. Arch. f. klin. Med. **99**:468, 1910.

69. Abercrombie: Cited by Clark, Am. J. M. Sc., N. S. **20**:106, 1850.

70. Clark: Am. J. M. Sc., N. S. **20**:106, 1850.

71. Kronig: Centralbl. f. inn. Med. **19**:178, 1898.

72. Fitzgerald and Everett: Brit. M. J. **2**:664, 1900.

73. Ponfick: Virchow's Arch. f. path. Anat. **50**:633, 1870.

74. Barlow: Brit. M. J. **1**:14, 1880.

knowledge of the physiology of the diaphragm betrayed by most writers on the subject. In particular, there is no evidence on record that the diagnosis of eventration of the diaphragm has ever been made by clinical application of such knowledge. Instead, various conflicting criteria and mechanical devices have been introduced as alleged aids in diagnosis. Some of these may be detailed:

1. Schlippe's procedure of measuring the variations in intragastric pressure during different phases of respiration.

Fig. 1.—Roentgenogram of Case 1. Viewed from the front.

2. Jamin's procedure of electrical excitation of the phrenic nerve.
3. By means of the fluoroscope: (a) The observation of so-called "paradoxical movement" of the affected half of the diaphragm. (b) Observation of the respiratory movement of the mediastinum.
4. By means of the fluoroscope and roentgenogram, the identification of the linear, arched shadow which extends from the mediastinum to the lateral thoracic wall.
5. The employment of pneumoperitoneum.

From a priori considerations, one might expect to gain pertinent information by the use of the device proposed by Schlippe. It was mainly through its employment that Hildebrand and Hess were enabled to arrive at a correct diagnosis in the case of the long-suffering Schneider. They demonstrated an inspiratory rise and expiratory fall in intragastric pressure, which is the reverse of what should occur if the stomach had invaded the thorax through a hole in the diaphragm. In view of their success one is surprised to find that subsequent investigators largely failed to utilize the method, but this fact is doubtless significant of its impracticability. Bergmann says that it may be of use, but fails to employ it in his own case. Minkowski found, with costal respiration, an inspiratory fall of intragastric pressure, and with abdominal breathing, an inspiratory rise. The inference to be drawn from this is obvious. A little consideration will suggest many more situations in which the results of the procedure must prove equivocal, and one need not go farther to show that it is worthless as a help in diagnosis.

Jamin's proposal to distinguish between normal and atrophic diaphragmatic musculature, and hence between hernia and eventration of the diaphragm, by fluoroscopic observation of the extent of the excursion of the two halves of the diaphragm caused by electrical excitation of the phrenic nerves in the neck, has not proved of service. Such a procedure, if employed in a normal subject in the interim between respirations, should theoretically eliminate the effect on the excursion of the diaphragm produced by the conflicting factor of activation of the intercostal muscles, and, therefore, should result in a degree of excursion directly proportional to the strength of the stimulus, the amount of diaphragmatic musculature, and the amount of normal conducting tissue in the phrenic nerve. Practically, however, the method is a very crude one, for the stimulation of the intact phrenic nerve in the human subject cannot be performed without collateral excitation of the scalene muscles, and possibly also of the upper intercostals, so that one cannot be sure that he is obtaining the necessary isolated effect predicated above. Furthermore, the cases under consideration are not in all respects normal subjects. If a diaphragm which is composed of normal muscle fibers, but is the seat of a hernia, shall have acquired a high fixation to the thoracic wall through the formation of pleural synechia (personally observed at operation), the test must necessarily fail. Again, the test will be positive for eventration in a patient who has normal musculature in the diaphragm, but has suffered an impairment in the conducting property of his phrenic nerve. Further factors complicating the results of this procedure are readily called to mind, and, as is to be expected, the test has not fared well in the hands of many investigators. Scheidemandel

observed total absence of excursion of the diaphragm on the affected side in his case of eventration. Reuss noted only a slight difference in the amount of excursion on the two sides. Minkowski states ambiguously that stimulation of the phrenic nerve gave contraction of the diaphragm on the affected side. Andree found slight downward excursion of the diaphragm on the affected side. Neumann noted only a minimal response in a case of gunshot injury of the phrenic nerve.

Fig. 2.—Roentgenogram of Case 2. Viewed from the back.

Assmann concludes, from the experience of others, and on theoretic grounds, that the method is not of any service in determining the diagnosis.

Hildebrand and Hess were the first to observe under the fluoroscope the so-called "paradoxical movement" (inspiratory ascent, expiratory descent) of the affected half of the diaphragm. Their case was later proved by necropsy to be one of eventration. Lotze, because of the

absence of this paradoxical excursion, made the diagnosis of eventration in his case, but the necropsy by Risel⁷⁵ revealed, not eventration, but hernia of the diaphragm. Schlecht and Wels observed the absence of paradoxical movement in their case, which was later proved by operation to be one of eventration. Neumann likewise noted its absence in a proved case of eventration. It was present in Bayne-Jones' proved case. Minkowski observed its presence during costal breathing, and absence with abdominal respiration. Assmann comments on the unreliability of the sign. These are the most conspicuous examples, although many other writers have remarked its presence or absence. In view of these contradictory observations, it is scarcely desirable to undertake a critique of the theory of "paradoxical" movement. As a test, it has no diagnostic significance.

Observation under the fluoroscope of respiratory excursion of the mediastinum has been made three times (Herz, Otten and Schefold, Minkowski). Herz noted in his case an inspiratory excursion of the mediastinum away from the affected side toward the sound side. He quotes Holzknacht, who first described this phenomenon in connection with unilateral paralysis of the phrenic nerve, as follows:

Since in the quiet expiratory phase an equal pressure exists in both halves of the chest, and falls only in the healthy side during inspiration, and since the intrabronchial communication cannot bring about an equilibrium quickly enough, both pressures are first of all equalized through displacement of the mediastinum which is effected by the stronger pull of the healthy side.

The explanation is essentially correct. The inspiratory increase of negative intrapleural pressure is normally brought about by an increase in the anteroposterior and transverse diameters of the thorax due to the activation and excursion of the intercostal muscles, with a concomitant maintenance, or increase, of the longitudinal diameter due to the activation and excursion of the diaphragm. In normal inspiration, the negative intrapleural pressure rises in value at an equal rate on the two sides, with consequent immobility of the mediastinum. If one-half of the diaphragm be deprived of its activation, the longitudinal diameter of the chest on that side will not be maintained or increased, but will be diminished, the negative intrapleural pressure will increase at an unequal rate on the two sides, and the mediastinum will consequently undergo inspiratory excursion toward the side which develops the greater negative pressure. In eventration of the diaphragm, or unilateral paralysis of the phrenic nerve, therefore, the mediastinum will exhibit inspiratory excursion toward the healthy side.

The observation of Otten and Schefold here comes into view. In a patient supposed to have eventration of the left half of the diaphragm,

75. Risel: München. med. Wchnschr. 54:637, 1907.

the heart and mediastinum were seen under the fluoroscope to move toward the left side during inspiration, with return toward the right side during expiration. This means that there must have been a greater negative intrapleural pressure created on the left side, but it is impossible to conceive of this if the left half of the diaphragm were the seat of aplasia. In the absence of other factors which might explain this phenomenon, we are, therefore, forced to reject this case from the category of eventration.

In discussing respiratory excursion of the mediastinum there is one other factor which must be considered. With normally functioning intercostal muscles and diaphragm, negative intrapleural pressure rises in value at an equal rate on the two sides only if the extensibility of the two lungs be unimpaired and there is no bronchial obstruction to the ingress of air. The following experiment illustrates the point:

EXPERIMENT.—A medium-sized dog (under morphin-chloretone anesthesia), with intact scaleni, intercostal muscles and diaphragm, breathing in a perfectly normal fashion, was given a complete obstruction to all except the lowest main bronchus on the right side, with consequent collapse of all except the lower lobe. When observed with the fluoroscope, the mediastinum and heart were seen to undergo an inspiratory excursion toward the right equal in extent to that exhibited in a downward direction by the right half of the diaphragm. Removal of the bronchial obstruction abolished all movement of the mediastinum; restoration of the obstruction caused the inspiratory excursion to reappear.

Negative intrapleural pressure increased at an equal rate on the two sides in this experiment. On the left side, it was equalized as it developed by the ingress into the bronchi of air under atmospheric pressure; on the right side, however, equalization of the rapidly rising negative pressure could not occur because of the bronchial obstruction, hence the disparity in pressure on the two sides, with resultant excursion of the mediastinum.

The third mention of mediastinal excursion is by Minkowski, who noted the movement toward the healthy side during inspiration. Mediastinal excursion in man is seldom a conspicuous phenomenon, even when conditions for its production are ideal—a fact which probably explains a want of any note of it in so many of the case reports of eventration of the diaphragm. The dog's mediastinum is less rigid, and therefore more easily responds to inequalities in negative intrapleural pressure.

A great part of the literature on eventration and hernia of the diaphragm is occupied with a discussion of the identity of the arched line which is seen in the skiagram to reach from the mediastinum to the lateral thoracic wall—the “*bogenförmige Schattenlinie*” of the Germans. Is it the silhouette of the strongly up-bellied, thinned-out

diaphragm, or is it the shadow cast by the distended magenblasse which has invaded the thorax through an aperture in the diaphragm? The arguments advanced pro and con, in the same case, and in different cases, remind one of the old shadow-picture of the horse and rider. At one instant he seems to be riding toward the observer, and in the next he is riding away. It has been sufficiently demonstrated that the assumption simply of a point of view toward this bow-shaped, linear silhouette cannot by any flight of the imagination be construed as diagnostic proof.

Recently Schlecht and Wels made roentgenograms of a case of eventration of the diaphragm after the production of a pneumoperitoneum. The procedure apparently offers a sure means of identifying the arched line mentioned above. In the presence of a hernia of the diaphragm, however, the dangers attendant on possible entrance of air into the pleural cavity must certainly be considered.

The key to the differentiation between hernia and eventration of the diaphragm lies in an application to the problem of a knowledge of the physiology of the diaphragm and intercostal muscles, a correct conception of which was denied to the earlier writers. Recently, however, this subject has been abundantly expounded by Hoover.⁷⁶ Given a case for differentiation, how shall we determine whether we have to deal with a weakened diaphragm standing in a very high position without solution of its continuity, or a diaphragm standing in a normal position, but the seat of an opening through which some of the abdominal viscera have invaded the thorax? We shall attempt to answer the question.

The movement of the costal margins during inspiration is the resultant of the activation of the intercostal muscles and the activation of the diaphragm. In this contest, the diaphragm labors under a distinct mechanical disadvantage, due to the considerable disparity which exists between the resultant line of traction of the diaphragm and the anatomic curve of the diaphragm. Consequently, under normal conditions the intercostal muscles obtain the mastery over the diaphragm with the result that the costal margins throughout their whole extent move away from the median line during inspiration. If the curve of one-half of the diaphragm becomes accentuated without the formation at the same time of synechia between the thoracic wall and the phrenic leaf, the result is an increase in the disparity between the resultant line of traction of the diaphragm and the curve of the diaphragm.

76. Hoover, C. F.: The Functions of the Diaphragm and Their Diagnostic Significance, *Arch. Int. Med.* **12**:214 (Aug.) 1913. Diagnostic Signs from the Scaleni, Intercostal Muscles and the Diaphragm in Lung Ventilation, *Ibid.* **20**:701 (Nov.) 1917. The Functions of the Intercostal Muscles, *J. A. M. A.* **73**:17 (July 5) 1919. The Diagnostic Significance of Inspiratory Movements of the Costal Margins, *Am. J. M. Sc.* **159**:633 (May) 1920.

This half of the diaphragm is thus reduced to a still greater mechanical disadvantage in its contest with the intercostal muscles for the mastery of the costal margin, and the latter, as a consequence, exhibits inspiratory divergence from the median line considerably in excess of the normal. In this exaggerated outward excursion the entire costal margin, from the xiphoid to the posterior axillary line, participates, and in comparison with the contralateral margin, its movement is not only one of greater extent, but it is accomplished more actively. In my case this asymmetry of movement of the costal margins was very striking.

In detecting movement of the costal margins, it is very important that the examiner combine inspection and palpation, and in palpation it is essential that the fingers be placed, not carelessly over the costal arches, but on the extreme ends of the ribs. It must be understood that the excursion of the costal borders (extreme ends of the ribs) is entirely independent of the excursion of the arcs of the ribs. The rib arc always moves upward and outward in "bucket-handle" fashion in response to normal activation of the intercostal muscles, whereas the direction of movement of the costal margins is the resultant of activation of the intercostals and diaphragm. One may find inspiratory convergence of the costal borders, but normal "bucket-handle" excursion of the arc of the rib; and conversely, impaired excursion of the rib arc but exaggerated inspiratory divergence of the costal margin. The last was a conspicuous feature in my case, and is of especial interest in a critical analysis of the observations on respiratory excursion of the thorax recorded in the literature on eventration of the diaphragm. Among the reports of cases which are adjudged genuine, one finds that twenty-one writers have made some mention of thoracic excursion. Eight have noted that the excursion on the two sides was equal; ten, that there was "slight lagging" of the affected side; one, that there was no movement whatever; and one, that the movement was better on the affected side. The subject is usually disposed of in a few vague words, and the observation is without significance either to the writer or to the reader. Reference may here be made to the obscure and inaccurate statements of Sailer and Rhein, Eppinger, and Wood. Observation of the movement of the costal borders has never before been made except by Funk, whose statement I have previously quoted. With this exception, all have failed to perceive the fact that the excursion of the arcs of the ribs and that of the costal margins (ends of the ribs) are quite independent of each other, and, although the former may conceivably be unaffected, or slightly impaired, depending on the degree of impairment of the extensibility of the lower lobe of the lung, caused by some additional factor, such as chronic pleurisy, the latter may at the same time exhibit an exag-

gerated outward excursion for an entirely different reason, viz., the great disparity which exists, in eventration, between the resultant line of traction and the curve of the diaphragm.

In hernia of the diaphragm, however, with which eventration has been invariably confounded, the conditions are entirely different. Here one finds a diaphragm, not aplastic and in a high position, but with intact muscle fibers and occupying an approximately normal position. It is, of course, conceivable that a very extensive aperture, occupying one-half or two-thirds of the phrenic leaf, would diminish the muscular power of the diaphragm to such an extent as to allow exaggerated outward excursion of the costal margins from intercostal activation, regardless of the anatomic curve of the diaphragm. This is the exceptional case, however, and one in which the diagnosis is not ordinarily a problem. In hernia of the diaphragm, then, the factors which control the movement of the costal margins are not essentially changed, and as a consequence one finds their excursion normal in extent and bilaterally symmetrical. If there should be any asymmetry of movement, it occurs as lessened outward movement on the affected side, due either to flattening of the diaphragm from the downward traction exerted on it by the abdominal viscera which have become adherent to its structure at the hernial orifice, or to the acquisition of a high insertion of the diaphragm from the formation of pleural synechia between it and the thoracic wall.

REPORT OF CASES

CASE 1.—J. A. R., male, aged 20 years.

Diagnosis.—Aplasia of the right lung and right half of the diaphragm, associated with cor dexter.

Present Illness.—Patient is not ill except for a slight furunculosis of the right axilla. He comes into the hospital for purposes of observation.

Past History.—Patient states that he has never been ill, but was always vigorous and able from childhood to compete fairly well with his playmates. He can engage in moderate exercise and perform a moderate amount of physical work without discomfort of any kind. Violent exercise, however, causes him to experience intense throbbing of his heart and a sense of weakness in the arms and legs, but he does not become short of breath. Patient discovered when still a child that his heart lay on his right side. If asked by his teacher to place his hand over his heart he would put his left hand across his right chest. When he was 8 years of age he was informed by medical examiners that his heart lay on the right side.

Physical Examination.—Thorax: There is a marked scoliosis of the mid and lower thoracic vertebrae, the concavity being to the right. The lower end of the sternum is well to the left, a perpendicular dropped from the middle of the thyroid cartilage intersecting the right sternal line at the level of the fifth rib. The transverse and anteroposterior diameters of the right thorax are considerably less than those of the left. Hepatic dulness is encountered at the level of the seventh rib in the midaxillary line on the right, whereas on the left the lower border of the pleural sinus extends to the ninth rib in the midaxillary line. On the right there is a marked diminution in the undulatory movement of the upper five ribs, together with distinct impairment in excu-

sion of the arches of the lower seven ribs. In an area on the right side bounded above by the clavicle, below by the liver, medially by the sternum, and laterally by the midaxillary line there is dullness to percussion, and a total want of tactile fremitus and breath sounds; in other words, there is no evidence that this area is occupied by lung. There is evidence, however, that the remainder of the right thorax, viz., the supraclavicular, suprascapular, interscapular, infrascapular, and the axillary and infra-axillary regions as far anteriorly as the midaxillary line, are occupied by normal lung. In these areas the percussion note is of the normal pitch, duration and resistance, the breath sounds are of normal character and intensity, and the tactile fremitus is normally transmitted. The left lung is normal throughout.

Heart: On the right side of the chest anteriorly there is plainly visible a diffuse precordial impulse occupying a quadrilateral area bounded above by the second rib, below by the fifth rib, medially by the right border of the sternum, and laterally by the anterior axillary line. In addition, there is a sharply localized systolic impulse, resembling a "choc en dome," visible at the right second intercostal space in a line intersecting the junction of the inner, and middle thirds of the clavicle. Over this area one palpates a strong systolic impulse and diastolic impact. The character of the heart sounds is consistent with the location of the apex at the fifth rib in the right parasternal line, and the conus arteriosus of the right ventricle at the second right intercostal space in the line above mentioned.

Costal Margins: With the patient in the recumbent position, the entire right costal margin, from the xiphoid to the posterior axillary line, is seen to undergo an inspiratory divergence from the median line distinctly in excess of that of the left—evidence of a want of activation of the right half of the diaphragm in its effect on the costal margins.

Clinical Diagnosis.—Taking into account the history, which clearly proved that the patient had never been ill, and the physical findings, which proved that the patient could not have a disease of his lung or pleura, Dr. Hoover made a diagnosis of aplasia of the right lung and right half of the diaphragm, associated with an embryonic displacement of the heart upward and to the right caused by this failure of development of the right lung and diaphragm.

Fluoroscopic Examination.—Under the fluoroscope, a great disparity between the longitudinal diameters of the two sides of the chest was apparent from the high position of the dome of the liver and the low position of the vault of the left diaphragm. During inspiration the right half of the diaphragm underwent no excursion of its own, but was drawn passively downward and to the left by the very lively excursion of the left diaphragm. There was no "paradoxical" movement of the right diaphragm, and the mediastinum could not be seen to undergo any excursion. The entire right half of the thorax was less transparent than the left. A striking feature was the fact that the heart failed almost entirely to cast a shadow. Its borders were extremely faint, and would probably not have been visible at all except for their slight mobility. This phenomenon was interpreted as being due to the fact that there was a want of aerated lung surrounding the heart. The roentgenograms were of the same character (Fig. 1). Whether the aorta arched over the right or the left bronchus was not discernible.

It should also be mentioned that the patient had a hypospadias, and that both his testes were intra-abdominal. His vital capacity was 3,200 c.c. A boy of his height (5 feet 8 inches) should have at least 4,500 c.c.

CASE 2.—E. C. W., male, aged 29 years.

Diagnosis.—Hernia of the left diaphragm.

Present Illness.—Patient states that on arising in the morning he is seized with a severe pain in the epigastrium, which gradually passes away after he has maintained the erect posture for a period of from two to three hours. The pain is usually associated with vomiting, especially if he eats breakfast. By

noon the discomfort has entirely disappeared, and he is always able to enjoy a hearty lunch and to retain it without difficulty. This disappearance of symptoms with the assumption and continued maintenance of the erect position has been constant throughout. There is nothing in the history to indicate disease of the intrathoracic organs, or local disease of the stomach or other abdominal viscera.

Past History.—When the patient was about 9 years old he was run over by a 1,500 pound delivery wagon, one of the rear wheels passing over his abdomen at about the level of the umbilicus. Two ribs on the left side were fractured. Following this injury he was in bed for six weeks, having pain in the abdomen and left shoulder. From that time, the patient was always more or less disturbed by the epigastric pain described, although it would occasionally be absent for long periods. During the past few years, however, the trouble has been growing distinctly worse. (Note: The full history of this injury was not obtained until after the diagnosis had been made. Patient at first dated the onset of the trouble only a few years previously.)

Physical Examination.—Thorax: Symmetrical, with no disproportion in the relations of the antero-posterior, transverse, or longitudinal diameters. The volume, density, and extensibility of the right lung are normal. At the base of the left thorax posteriorly, in an area bounded above by the sixth rib, medially by the spine, and laterally by the posterior axillary line, the percussion note is dull and has a tympanitic quality, tactile fremitus is increased, and the breath sounds are high pitched and tubular in character. No râles. The tympanitic quality of the percussion note is interpreted as Skodaic resonance due to relaxed lung. In this area the coin sound and succussion splash are occasionally demonstrable. The percussion note, tactile fremitus, and breath sounds are normal in character throughout the remainder of the left lung. The excursion of the arcs of the ribs, and that of the costal margins, is equal and active on both sides. The fact that the costal borders undergo symmetrical inspiratory divergence is proof of normal activation of both halves of the diaphragm, for normally activated intercostal muscles, unopposed by the factor of activation of the diaphragm, cannot fail to bring about exaggerated inspiratory divergence of the costal margins. The left half of the diaphragm, therefore, cannot be the seat of aplasia. Furthermore, a normal excursion of the arches of the ribs cannot take place in the presence of impaired extensibility of the underlying lung. Hence, chronic pleurisy does not explain the dullness at the base of the left thorax, nor does partial infiltration of the lung account for the tympanitic percussion note. Hydropneumothorax is similarly excluded. The physical signs could be interpreted only as dependent on the invasion of the thorax by some abdominal viscus.

Heart: There is no visible or palpable precordial activity. Percussion shows that the heart occupies a normal position, the right border being located at the right sternal line, and the left at the left midclavicular line. Auscultation reveals nothing abnormal during systole or diastole.

Clinical Diagnosis.—From the physical signs, without having obtained the history of injury, Dr. Hoover made the diagnosis of hernia of the left diaphragm.

Fluoroscopic Examination.—Under the fluoroscope there was no disparity to be seen between the longitudinal diameters of the two sides of the chest, and the diaphragm underwent a normal excursion on both sides. When the patient was given barium mixture to drink, the stomach was seen to lie almost entirely in the left pleural cavity, its upper level reaching to the third rib anteriorly. There was no displacement of the heart (Fig. 2).

COMMENT

In a great proportion of the cases of hernia and eventration of the diaphragm, as reported in the literature, there has been a striking uniformity in the physical signs from palpation, percussion, and auscul-

tation. It is for this reason that a study of the evidences of activation of the diaphragm is of paramount importance. This uniformity did not extend in its entirety to our two cases, partly because of the co-existing aplasia of the lung in the case of eventration. In spite of this fact, the most important difference in the physical signs of the two cases was apparent in the behavior of the costal margins, the interpretation of which enabled us to make the diagnosis by direct physical examination without instrumental aid.

CONCLUSION

1. The literature on the subject of "eventration" of the diaphragm is critically reviewed, chiefly from the standpoint of diagnosis.
2. Diagnostic criteria are critically discussed. Emphasis is laid on the necessity for a careful study of the inspiratory excursion of the costal margins in the attempt to differentiate eventration from hernia of the diaphragm.
3. The evidences for activation, or want of activation, of the diaphragm in hernia and eventration are illustrated by the presentation of cases.

SUMMARY OF BIBLIOGRAPHY

Articles dealing with cases in which the diagnosis of "Eventration of the Diaphragm" is regarded as proved: Ref. Nos. 1, 12, 13, 14, 15, 16, 19, 21, 22, 23, 26, 28, 32, 48, 49, 51, 52, 58, 64, 65, 66.

Articles dealing with cases in which the diagnosis of "Eventration of the Diaphragm" is not proved, but is regarded as reasonably certain: Ref. Nos. 3, 6, 8, 11, 17, 18, 20, 25, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 50, 53, 54, 56, 60, 61, 62, 63.

Articles dealing with cases in which the diagnosis of "Eventration of the Diaphragm" is neither proved nor reasonably certain: Ref. Nos. 5, 9, 10, 51a, 55, 67, 68.

Articles inaccessible to the author supposed to present cases of Eventration: Ref. Nos. 57, 59, and

Cordier: *Progrès méd.* **35**:193 (May 1) 1920.

Kwasek: Cited by Schlecht and Wels, loc. cit.

Articles dealing with diagnostic signs from the intercostal muscles and the diaphragm are listed under Ref. 76.

Further references, not cited in text:

Editorial: *Med. Rec.* **93**:72, 1918.

Giffin: *Ann. Surg.* **55**:388, 1912.

Grosser: *Wien. klin. Wchnschr.* **12**:655, 1899.

Kienbock: *Wien. klin. Wchnschr.* **11**:538, 1898.

Leichtenstern: *Berl. klin. Wchnschr.* **11**:497, 515, 539, 1874.

Lenormant: *Presse méd.* **20**:350, 1912.

Stockton: *Buffalo M. J., N. S.* **38**:97, 1898.