

leads directly back to social conditions, which social conditions may or may not be dependent upon industrial conditions. The psychoneuroses, therefore, may become a good barometer of certain social states dependent upon industrial conditions, and while it is known that the social state of the worker has been investigated fully, still we do not think that it has been appreciated that many of the specific manifestations of illness are outward indications of certain types of social conditions that are undesirable. It will be seen then that a correlation between the work of the psychiatrist and neurologist and the social worker is possible along these lines. This paper merely bespeaks a recognition of the advantage of this correlation, which if pursued would be seen to offer many possibilities for work.

## THE TOPOGRAPHY OF THE CARDIAC VALVES AS REVEALED BY THE X-RAYS.<sup>1</sup>

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FOR many years attempts have been made to determine definitely the exact spots on the anterior chest wall under which lie the valves of the heart. The method by which studies in this direction have been made has consisted of the thrusting of long pins into the thorax and then opening the latter and noting the points at which the pins pierced the heart. From data thus obtained diagrams were constructed which were supposed to depict the valves in their relation to the anterior chest wall. That this method is inaccurate is demonstrated rather forcibly by the lack of unanimity in the descriptions given by various authors. In the following excerpts we present the opinions of a number of authorities, and it is interesting to note that the more superficially located is the valve the more nearly do the different authors agree, while the deeper lies the valve the more widely do the writers disagree.

<sup>1</sup> Read before the College of Physicians of Philadelphia, October 2, 1912.

*Aortic*: Behind the junction of the third left costal cartilage with the sternum, one-fourth covered by pulmonary valves. *Pulmonary*: Behind the upper border of the third left costal cartilage and the adjacent part of the second left intercostal space. *Tricuspid*: Behind the left half of the sternum at the fifth costal cartilage and the fourth intercostal space. *Mitral*: Behind the left half of the sternum at the third intercostal space and at the fourth intercostal space.<sup>2</sup>



FIG. 1.—In this x-ray photograph every valve is shown with great clearness. On account of cardiac hypertrophy and sinistro-displacement, all the valves lie well to the left of the sternum. P, pulmonary valve; A, aortic valve; M, mitral valve; T, tricuspid valve.

*Aortic*: Behind the sternal end of the third left intercostal space. *Pulmonary*: A little above and behind the third left chondrosternal junction. *Tricuspid*: Behind the middle of the sternum at the fourth intercostal space. *Mitral*: Behind the fourth costal cartilage at the left border of the sternum.<sup>3</sup>

<sup>1</sup> C. A. Gibson, *Diseases of the Heart and Aorta*, 1898, p. 38.

<sup>2</sup> John B. Deaver, *Surgical Anatomy*, 1903, p. 409.

*Aortic*: Slightly below and internal to the pulmonary on the level with the third space between the midsternal and the left sternal line. *Pulmonary*: Behind the sternal end of the third left costal cartilage. *Tricuspid*: On the horizontal line between the two sternal ends of the fifth cartilage at the point intersected by a line drawn from the sternal end of the third left cartilage to the upper border of the sternal end of the seventh on the right. *Mitral*: Behind the sternal end of the third left space.<sup>4</sup>



FIG. 2.—Frontal section of the thorax, the x-ray picture of which is shown in Fig. 3. The tuberculous cavities of the left lung are well shown in the x-ray plate.

*Aortic*: Lower border of the third left costosternal junction. *Pulmonary*: Upper border of the third left costosternal junction. *Tricuspid*: Just to the left of the midsternal line level with the fourth space. *Mitral*: Fourth left costosternal junction.<sup>5</sup>

*Aortic*: The third left intercostal space. *Pulmonary*: Third left costosternal junction. *Tricuspid*: Midsternum at the level of the fifth costosternal junction. *Mitral*: Fourth left costosternal junction.<sup>6</sup>

<sup>4</sup> de Nœuville, *Essentials of Anatomy*, 1911, p. 183.

<sup>5</sup> Henry Gray, *Anatomy*, Philadelphia, 1908, p. 559.

<sup>6</sup> C. Toldt, *Atlas of Human Anatomy*, New York, 1904, Part 5, p. 586.

*Aortic*: Lower border of the third left costosternal junction. *Pulmonary*: Upper border of the third left costal cartilage close to the sternum. *Tricuspid*: Behind the sternum at the level of the fourth interspace and anterior extremity of the fifth costal cartilage extending down to the right almost as far as the sixth chondrosternal junction. *Mitral*: Behind the left half sternum at the level of the fourth chondrosternal junction.<sup>7</sup>



FIG. 3.—X-ray photograph of thorax, a frontal section of which is shown in Fig. 2. Of the cardiac valves only the semilunars show with clearness. The tuberculous cavities of the left lung and the internal mammary vessels are well demonstrated. P, pulmonary valve; A, aortic valve.

*Aortic*: Opposite the inner lower border of the third left costal cartilage. *Pulmonary*: Upper border of the third left costal cartilage at its sternal junction. *Tricuspid*: Behind the sternum from the opposite fourth left interspace to the fifth right interspace. *Mitral*: Left edge of the sternum at the level of the fourth left costal cartilage.<sup>8</sup>

*Aortic*: Behind the third intercostal space, close to the left side of the sternum. *Pulmonary*: In front of the aortic valve,

<sup>7</sup> L. B. Rawlings, *Landmarks and Surface Markings of the Human Body*, London, 1908, p. 37.

<sup>8</sup> C. R. Whittaker, *Essentials of Surface Anatomy*, London, 1912, p. 29.

behind the third left chondrosternal junction. *Tricuspid*: Behind the middle of the sternum, about the level of the fourth costal cartilage. *Mitral*: Behind the third intercostal space, about one inch to the left of the sternum.<sup>9</sup>

*Aortic*: Middle of the sternum, at the level of the third costal cartilage. *Pulmonary*: Second intercostal space, somewhat to the left of the edge of the sternum. *Tricuspid*: Midway between



FIG. 4.—Frontal section of the thorax, the x-ray picture of which is shown in Fig. 5. There should be noted the cut surfaces of the aorta, the pulmonary artery, and the left auricular appendix, all of which appear clearly in Fig. 5.

the third left and the fifth right chondrosternal articulation. *Mitral*: Beneath the third left chondrosternal articulation.<sup>10</sup>

*Aortic*: Behind the left half of the sternum at the lower border of the third costal cartilage. *Pulmonary*: At the upper border of the third left chondrosternal articulation. *Tricuspid*: From the midsternum at the level of the fourth costal cartilage to the

<sup>9</sup> John H. Musser, *Medical Diagnosis*, 1900, p. 595.

<sup>10</sup> Herman Sahli, *Diagnostic Methods*, 1905 (quotes Luschka), p. 247.

fifth chondrosternal junction. *Mitral*: Behind the left half of the sternum at the level of the fourth costal cartilage.<sup>11</sup>

*Aortic*: Behind the midsternum at the level of the third intercostal space. *Pulmonary*: Behind the third left chondrosternal articulation. *Tricuspid*: Behind the lower portion of the sternum at the level of the fourth intercostal space. *Mitral*: Behind the fourth chondrosternal articulation.<sup>12</sup>



FIG. 5.—X-ray picture of the thorax, a frontal section of which is shown in Fig. 4. The valves in this plate are photographed rather faintly. They are more widely separated than is usually found, the condition being probably due to cardiac dilatation. The aorta, the pulmonary artery, the left auricular appendix (see Fig. 4), the pulmonary veins and the internal mammary and coronary arteries are shown with great clearness. P, pulmonary valve; A, aortic valve; M, mitral valve; T, tricuspid valve.

*Aortic*: Behind the left half of the sternum, opposite the lower part of the third chondrosternal articulation. *Pulmonary*: Behind the third left chondrosternal articulation. *Tricuspid*: Behind the midsternum, opposite the fourth chondrosternal articulation and

<sup>11</sup> J. C. Da Costa, Jr., 1911, p. 298.

<sup>12</sup> Joh. Sobotta, Atlas and Text-book of the Human Anatomy, American Translation, 1906, ii, 172.

the fourth intercostal space. *Mitral*: Behind the left half of the sternum opposite the third interspace and the fourth chondro-sternal articulation.<sup>13</sup>

*Aortic*: Behind the left half of the sternum a little below and to the right of the pulmonary. *Pulmonary*: Behind the sternal end of the third left costal cartilage. *Tricuspid*: Almost behind



Fig. 6.—Frontal section of the thorax, the x-ray picture of which is shown in Fig. 7.

the midsternum, opposite the fourth interspace and the fifth chondro-sternal articulation. *Mitral*: Opposite the sternal end of the third left interspace.<sup>14</sup>

*Aortic*: The third interspace close to the sternum. *Pulmonary*: At the junction of the third rib with the left side of the sternum. *Tricuspid*: Behind the sternum, near the middle line about the

<sup>13</sup> D. J. Cunningham, *Text-book of Anatomy*, 1906, p. 789.

<sup>14</sup> G. A. Piersol, *Human Anatomy*, 1907, p. 692.

level of the fourth costal cartilage. *Mitral*: Behind the third intercostal space about one inch to the left of the sternum.<sup>15</sup>

*Aortic*: Behind the inner edge of the third costal cartilage, intercostal space, and contiguous portion of the sternum on the left side. *Pulmonary*: A little higher and more to the left. *Tricuspid*: Below and a little to the left, a line drawn from the inner

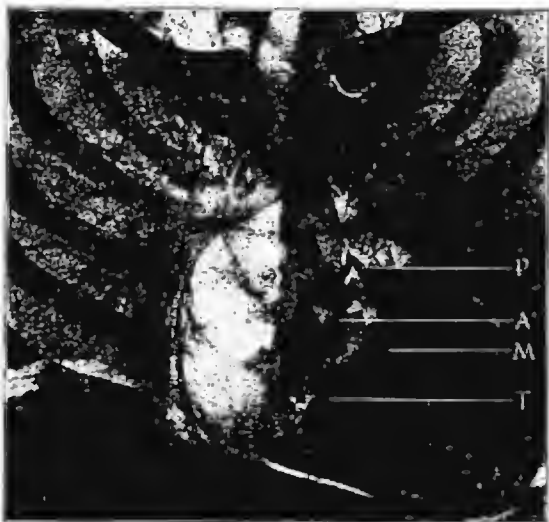


FIG. 7.—X-ray picture of the thorax, a frontal section of which is shown in Fig. 6. The individual leaflets of the pulmonary and aortic valves are shown with unusual distinctness. All the valves lie approximately one rib below what is described as their normal position. P, pulmonary valve; A, aortic valve; M, mitral valve; T, tricuspid valve.

end of the third costal cartilage on the left to the inner end of the sixth right costal cartilage. *Mitral*: Behind the third intercostal space about one inch to the left of the sternum.<sup>16</sup>

With the view of settling definitely these moot points the present study was undertaken. In the planning of our investigations the problem naturally divided itself into two parts, (1) the preparation of the material so that conditions existing during life would be present for postmortem study, and (2) the depiction of such con-

<sup>15</sup> H. Morris, *Human Anatomy*, Philadelphia, 1895, p. 972.

<sup>16</sup> J. Leidy.



ditions with all possible sources of error eliminated. In order to secure these desiderata the following plan was evolved: Each cadaver on being delivered at the University of Pennsylvania was injected with 10 per cent. formaldehyde solution and then put into cold storage. When thorough freezing had been secured the head and neck, the upper extremities, and the lower part of the trunk were cut off. The thorax was then cut into frontal sections about one inch thick, the cuts being made parallel with the anterior surface of the chest. Each section was then cleaned up by removing all blood clots and saw detritus from the heart cavities and large bloodvessels. In this manner we avoided distortion, since all parts were hardened in the position which they occupied at death.

To depict the conditions present we adopted the following procedure: Each valve leaflet was carefully dried and then painted with the thickest possible lead paint. This was readily done, for the sections were so thin that all the valves were accessible, and in most instances it was possible to paint both surfaces of the entire eleven leaflets.

Finally, after the valves were painted, the sections were superimposed, with the anterior one below, and an x-ray photograph taken. In order to show with greater clearness the relations of the valves to the sternum and ribs, that section of the thorax which comprised the posterior portion and included the vertebral column, the posterior section of the ribs and the thick spinal muscles, was not used. By discarding this portion nothing was lost and much was gained in clarity, since the vertebrae and the posterior part of the ribs were eliminated from the pictures.

In the course of our investigations fifteen bodies were sectioned. It was soon evident, however, that a much larger number would have to be studied before any definite conclusions regarding normal relations could be reached, since many of the cadavers represented pathological alterations in the topography of the thoracic viscera. Often the heart was displaced as the result of extensive pulmonary tuberculosis, or of hypertrophy of the heart. Other lesions, such as pericardial effusions, atelectatic lungs, etc., furnished additional sources of error.

We therefore offer this communication in the nature of a preliminary report, and in demonstration of an entirely feasible and hitherto unemployed method of studying post mortem the topography of the heart valves in health and disease.

In conclusion, we wish to express our indebtedness to Dr. Henry K. Pancoast for his kindness in furnishing us with the x-ray photographs.