[From Schenckius: Observationum Medicarum, Francofurti, 1609.]

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I. DOMINIC JOHN CORRIGAN; HIS PLACE IN THE DEVELOPMENT OF OUR KNOWLEDGE OF CARDIAC DISEASE

II. THE WATER-HAMMER PULSE*

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THE idea of celebrating the 100th anniversary of Dominic Corrigan's paper on Aortic Regurgitation is a happy one, for that event marked an epoch in the development of cardiac diagnosis. One hundred years ago the general practitioner and the general public knew little about the subject, experts were few, and their knowledge limited. As an index to the situation, just as Laennec was discovering mediate auscultation American physicians were offered an English translation, by Edwin A. Atlee, M.D., of Philadelphia, of a work on the Practice of Medicine by Dr. Joseph Lieutaud,[1] First Physician to Louis XV, and one of the leading medical authors and authorities of France in his time. If the reader expected novelties in the new edition of a work fifty years old, he was disappointed. The subject of heart disease was limited to Palpitation and Syncope, and these chapters showed no advance over the work of Aretaeus the Cappadocian, who lived in the time of Vespasian and Nero, and whose vivid descriptions of disease were copied by all writers in the intervening centuries. Palpitation was assigned to the same group as tremor, convulsions, and various kinds of rigors, such as those from exposure to cold. Two centuries before Corrigan, in 1628, Willian Harvey had made clear the essential features of heart mechanism, and, although he had no

* Read in part at a meeting of the Los Angeles County Heart Association, Sept. 23, 1932, in honor of Dominic John Corrigan.

knowledge of the capillary circulation, he realized the functions of the heart, had heard the sounds made by that organ, and described a case of cardiac infarct with rupture.

In the two centuries between Harvey and Corrigan, progress was small. Even before Harvey there were a few observations on diseased hearts, and the industrious John Forbes[2] found half a dozen between 1497 and 1618. One of these is mentioned in the Osler Catalogue, viz., Eustachius Rudius, "de Naturali atque morbosa cordis constitutione," Venet., 1600. After Harvey's publication references to symptoms and anatomical alterations did not become more numerous until the 18th century when some important monographs appeared. The most noteworthy were those of Vieussens,[3] Lancisi,[4] Jean Senac,[5] and J. F. Meckel.[6] Morgagni's "Seats and Causes of Disease Investigated by Anatomy," 1761, like the foregoing and some others, gave descriptions of anatomical alterations in the heart that struck the attention of reporters, and Morgagni described more symptoms than the others, although most of his clinical facts were obtained from the family physician, or from neighbors of the patients. The next contribution of moment was based on the clinical lectures of Jean Nicolas Corvisart,[7] and first published in 1806. In that book we can learn how the industry and genius of Corvisart made him the founder of clinical medicine in France, and secured for him the confidence and influence of Napoleon. Corvisart realized the importance of Auenbrugger's discovery of percussion more than any contemporary, and by the application of his anatomical knowledge, his clinical observation, his cultivated touch and percussion, he advanced immeasurably cardiac diagnosis. He recognized valvular disease, but could not assign the symptoms to the valve affected. To do that it was necessary to have a new method of investigation of cardiac activity, and this Laennec had the merit of giving the world in mediate auscultation. By this discovery the prediction of Robert Hooke was realized after more than a century and I make no excuses for quoting that inventive and versatile genius in this epoch of extraordinary inventions. I have taken an extract from John Tyndall's celebrated "Lectures on Sound"; as he said, "a quaint and beautiful extract from the writings of that admirable thinker, Dr. Robert Hooke. It will be noticed," continued Tyndall, "that the philosophy of the stethoscope is enunciated in the following passage, and another could hardly be found which illustrates so well that action of the scientific imagination which, in all great investigators, is the precursor and associate of experiment."

Hooke wrote:

> There may also be a possibility of discovering the internal motions and actions of bodies by the sound they make. Who knows but that, as in a watch, we may hear the beating of the balance, and the running of the wheels, and the striking of the hammers, and the grating of the teeth, and multitudes of other noises; who knows, I say, but that it may be possible to discover the motions of the internal parts of bodies, whether animal, vegetable, or mineral, by the sound they make; that one may discover the works performed in the several offices and shops of a man's body, and thereby discover what instrument or engine is out of order, what works are going on at several times, and lie still at others, and the like. . . . I have been able to hear very plainly the beating of a man's heart, and it is com-

mon to hear the motion of wind too and ro in the guts, and other small vessels; he stopping of the lungs is ea~ily discovered by the wheezing, the stoppmg of the head by the humming and whistling noises, the slipping too and fro of the ·oin.t<. in many c,i,;es. by crackling. and the l~ke.... So to their becoming sensible they require either that motions be increased, or that the organ be made more nice and powerful to sensate and distinguish them.

But this suggestive passage had no more effect upon physicians than had the tradition that Hippocrates utilized rhe sound of the thoracic splash in the diagnosis of pleural diseases. A few inquisitive men now and then through he next century after Hooke recorded range noises in the chest. Some of the patients, especially those that preented sounds compared to those of aneurismal varix, probably had val--ular disease, but no one systematically and methodically followed up he subject. F. J. Double,[8] for example, in 1817 said he used direct auscultaion of the lungs and heart but he gave no practical details. Even the disclosure of the clinical value of ounds made on the body by percusion did not soon lead to the study of noises originating there. But after Corvisart revived percussion, his associates began the practice of auscultaion with the ear to the chest. Among these was R. T. H. Laennec, then about twenty-five years old. But in hospital practice such work was unpleasant, so that it was not always done. In private practice obesity, and sometimes a fear of offending modesty, interfered. But in Laennec the urge to use his ears was strong, and when one day, crossing the courtyard of the Louvre, he saw some children listening at one end of a beam of wood to the c,rnnrl rn£irlP hy ctrikinP- with a nin on the other end, he had the inspiration of mediate auscultation. With an improvised stethoscope he tried this in the hospital and soon after on a fat and bashful private patient. With the enthusiastic aid of his staff he accumulated material so successfully that in two years he read a communication on the subject before the Academie des Sciences, and a year later published the first edition of his book.[9]

In contrast to the experiences of Harvey and Auenbrugger with their medical innovations, Laennec rapidly acquired disciples. In France, and especially in England, bright young medical men took up the new art with enthusiasm, but also with constructive criticism, for Laennec had many obscurities and imperfections in his text, especially in the chapters on the organs of circulation. William Stokes, James Hope, C. J.B. Williams and others strove with notable success to make the new knowledge more simple and more accurate. Stokes and Dominic John Corrigan graduated in the same class in medicine at Edinburgh, in 1825. Stokes began writing early, with a textbook on auscultation.[10] In the Preface, Stokes modestly spoke of the excellent books already available, and made a brief claim for the practical value of auscultation. To the text he added an abridged translation of Andral's "Thesis on Expectoration," Paris, 182 r. The whole made a book of 226 pages.

Corrigan settled in his native Dublin and busied himself with dispensary work, with the idea he later expressed in a lecture, quoting Bichat to the effect that the student should investigate disease rather than read about it. By 1829 he thought he had somethinz to report, and wisely chose a

conspicuous medium. The L?nd?n *Lancet,* begun in 1823, was m its most militant period. The celebrated libel suit of Cooper vs. Wakley, the editor, was appearin& weekly without concern over possible contempt of court. The trial of bo1y-snatcher **Burke** was also attractrng attention. In the number for February 7, 1829, is a paper by Corrigan,[11] who was then Lecturer on the Institutes and Practice of Medicine, and one of the Physicians of the Sick-Poor Institution, Dublin. This is the account of a case of aneurysm, well presented and well discussed from the standpoints of diagnosis and treatment, and proving the value of the new art of auscultation, of which many physicians were still skeptical. Corrigan also expressed the hope of improvement in treatment, for which there was abundant need. The "singular pulsations" in the brachials, carotids, and other arteries, as if the vessels, previously empty, had suddenly become filled, Corrigan thought signs of aneurysm, and that they might help in the diagnosis of future cases. But in his article on aortic regurgitation he had to admit there was aortic incompetence in addition to the aneurysm, in the case just cited, and that the pulsations were due to valvular disease.

In the next volume of the *Lancet,*[12] Corrigan published an "Inquiry into the Causes of Bruit de Souffiet and Fremissement cataire." In the early days of auscultation no effort was made by English writers to translate the new technical terms, which were simply words from the French vernacular. Even now we still use many words, "rale" and "bruit," although rattle and murmur are just as descriptive. **Laennec thought bruit de** souffiet, that is a noise like that produced by a hand-bellows, was due to spasm, and he was also una~le to explain fremissement or thrill. Corrigan discussed both phenomena, and in the next number of the *Lancet*[13] he described some experiments with pipes, that need not be detailed, ~nd explained the signs on purely physical causes. He there made the first suggestion of what Chauveau and Savart long afterwards described as "fluid veins," or eddies, in the vessels. The style of the article is calm and logical, in contrast to the controversial manner of some contemporary writers.

Corrigan published a paper "On the Motions and Sounds of the Heart,"[13a] in which he reported investigations carried out with the assistance of J. C. Ferguson and P. Hunt, and directed chiefly against the explanations of Laennec. He pointed out that the cardiac impulse is caused by the contraction of the auricles; the first sound by the "rush of blood from the auricles into the dilating ventricles," the "second sound by the striking together of the internal surfaces of the ventricles." The article brought out an Editorial in the *Lancet,* September 18, 1830, p. 964, and a somewhat bitter review by James Hope, in the *Medico-Cbirurgical Review,* July 1, 1830, pp. 122–133. Hope admitted that his ideas on the heart sounds were not very different from Corrigan's, but he did not accept Corrigan's view that the impulse of the heart is not the gauge of hypertrophy of the ventricles.

Studies on the motion of the heart, and the causes of the sounds were being actively carried out about that time, as they had been since the time of Harvey. Having no recording apparatus the results were contradictory,

and Corrigan's opinion of such work can be understood from a passage in a review of Bouillaud's book on 'Heart Disease" in the *Dublin Journal* (9: 489, 1836):

> Senac tells us that the movements of the heart having given rise to much controversy, the Royal Academy ordered a grand field day, when actual inspection should he made in the presence of the members of the movements of the heart in living animals, and then by their evidence and their fiat, all doubt should be removed. The day came; the animals were tortured; the movements looked at; and the Academy came to the conclusion that it could come to no conclusion at all.

Soon after, Corrigan[14] had a paper "On the Epidemic Fever of Ireland." This is a strong presentation of the relation of starvation to typhus fever in Ireland, with statistics and details of living conditions, and purposely avoiding discussion of contagion. It shows that Corrigan's interest and activities were not limited to physical diagnosis, but included general medical and social-medical topics. In the famine of 1817–1818 one sixth of the population of Ireland passed through the fever hospitals. More poor than rich were affected, with a mortality of one to thirty, whereas of the rich, one-third of those affected died. The article was reprinted as a pamphlet of thirty-three pages in 1841, and the *London Medical Gazette* (n. s. 2: 385), in a review in 1846, also a famine year, spoke of the author as a man of humane feeling, and a sound physician. In this latter year Corrigan published a series of lectures on Fevers that do not require consideration now.

The article that established Corrigan's fame was published in the *Edinburgh Medical and Surgical Journal*, in the number for April 1, 1832, pp. 225–245.[15] Corrigan was then one of the Physicians to the Charitable Infirmary, Jervis Street, Dublin, and Consulting Physician to St. Patrick's College, Maynooth. The beginning of this article illustrates Corrigan's terse and clear style:

> The disease to which the above name is given has not, so far as I am aware, been described in any of the works on diseases of the heart. The object of the present paper is to supply that deficiency. The disease is not uncommon. It forms a considerable proportion of cases of deranged action of the heart, and it deserves attention from its peculiar signs, its progress, and its treatment. The pathological essence of the disease consists in inefficiency of the valvular apparatus at the mouth of the aorta, in consequence of which the blood sent into the aorta regurgitates into the ventricle. This regurgitation, and the signs by which it is denoted, are not necessarily connected with one particular change of structure in the valvular apparatus, and hence the name Permanent Patency of the mouth of the aorta, or Inadequacy of the Aortic Valves, has been chosen as simply expressing such a state of the parts as permits the regurgitation to occur.

Corrigan says he described the disease for some years as "inadequacy of the aortic valves," but took up "permanent patency" following Elliotson. The conditions in the valves are briefly described, viz.: reticulation; rupture; tightened or curled; dilatation of the mouth of the aorta. The general symptoms are uncertain and unsatisfactory. There are frequent convulsive attacks of cough; dyspnea; sense of straitness and oppression across the chest; palpitation after exercise; sounds of rushing in the ears; inability to lie down. None of these is essential. The physical signs are: (1)

visible pulsations of the arteries of the head and upper extremities, (2) bruit de soufflet in the ascending aorta, carotids, and subclavians, (3) bruit de souffiet and fremissement, or a peculiar rushing thrill felt by the fingers in the carotid and subclavian arteries.

These three are so intimately connected with the pathological cause of the disease, and arise so directly from mechanical inadequacy of the valves, that they afford unerring indications of the nature of the disease. In conjunction with these may be reckoned the pulse, which is invariably full. There are singular pulsations in the superficial vessels. From its singular and striking appearance, the name of visible pulsation is given to this beating of the arteries. . . . The sudden and great diastole of the vessels makes the visible pulsation. This is more distinct in the upper parts; more when standing than when lying.

One patient discovered he could increase the pulsations by elevating his arms. Elevating the legs caused similar phenomena there. Corrigan recalled his discussion of bruit de souffiet previously referred to, his experiments, and the description of the abnormal currents. He noted the double murmur in some cases. A patient discovered this for himself, and explained it by the blood rushing to and from the heart. Only one case was seen as early as twenty years. Only one in eleven had had rheumatism. Many gave histories of "inflammatory disease of the chest." Painful symptoms occurred in the last stage. Death was from exhaustion, and not pulmonary congestion, as in mitral disease. The duration varied from two to seven or eight years.

Corrigan gave the differential diagnosis, beginning with aortic stenosis, with its slow pulse. In aortic inadequacy the pulse is "invariably full and swelling." The resemblance to the pulsations in aortic aneurysm was discussed. Both may show pulsations at the aortic notch. He made the statement, "in permanent patency of the mouth of the aorta the fatal result is never sudden." He described a "nervous palpitation," in the arteries simulating aortic disease, and even with murmur under excitement. He emphasized that pressure with the stethoscope was to be avoided in auscultation of the arteries. He discussed the erroneous treatment of previous authors. Corvisart, for example, tried to diminish the general strength of the patient and also that of the heart. Laennec and also Bertin used general and local bleedings, low diet, and digitalis. The treatment was essentially antiphlogistic, and calculated to produce debility. Corrigan said:

A little reflection on the nature of the disease before us will show that these principles are inapplicable both to the treatment of the valvular alterations, and of the hypertrophy of the left ventricle which accompanies that alteration. The physical condition requires hypertrophy and so we need strengthening of the general constitution, which will give proportional vigor to the heart. Hence there should be general and sufficient diet of animal and vegetable food, and at the same time abstinence from those beverages, such as malt liquors, which increase the mass of the fluids. The patient may attend to business or profession, but should avoid so much attention as to produce debility. . . . **And** as there is among patients who have learned that they are afflicted with heart disease an universal dread of sudden death, it is necessary to undeceive them on this point; and in the present instance it can be done with perfect safety, as the

termination of the disease is never sudden.

He cited a case showing the bad effect of other treatment, with bleeding after bleeding, blister after blister, starvation, and digitalis. With a change on the lines Corrigan indicated, improvement followed. He objected to digitalis because it makes the pauses longer, when an increased rate would be better. Inflammatory complications, pneumonia, rheumatism, etc., require prompt and effective depletion. "Bleeding in these cases never produced fainting," but a full dose of opium should be given after bleeding. No medicine would help the valves. Salivation might be tried early in rheumatism. Finally, he repeated the statement about the improbability of sudden death.

It is unnecessary to indicate the good and bad points in this account. A short time after its publication Corrigan sent a paper "On the Treatment of Recent Catarrh" to the *Dublin Journal of Medicine and Chemistry* (1: 7, 1832), in which he said: Had I known at an earlier date of the forthcoming of an Irish Periodical, I might have had a better offering to present," so his own opinion of the paper was probably a good one. In the same number of the *Dublin Journal* there was an abstract of the Permanent Patency article (pp. 242–243).

As so often happens when medical novelties are made public, claims of priority arose. Old cases were exhumed from the literature. The most noteworthy of the very early cases were those of William Cowper, in 1706, and Raymond Vieussens in 1715. Both accounts are easily accessible in the admirable "Classic Descriptions of Disease" by Dr. Ralph H. Major, 1932, and I omit references. Neither account, I need hardly say, led others to seek for and report similar cases. Vieussens' case was very striking, and leaves no doubt as to the nature of the disease, while the description of the pulse is so good that it is worth repeating (Ref. 3, p. 107). A man of thirty-five, sick for many years, was found prostrated, with pale and puffy face. "The pulse was very full, very fast, hard and unequal, and so strong the arteries on both sides struck the fingers like a tense cord vibrating violently. I never saw and never hope to see the like." Post mortem, extensive disease of the aortic semilunar valves was found.

The most important claim made was that regarding the paper of Thomas Hodgkin. It is interesting that the claim was made by Samuel Wilks in 1871.[16] In this Wilks pointed out that Corrigan laid stress chiefly on throbbing and visibility of the smaller arteries, less on the collapsing pulse, and that Hodgkin, five years before Corrigan's paper, gave a far better account and had a far deeper insight into aortic disease than any other man of the year 1827. It is therefore necessary to examine Hodgkin's paper and see its relation to the subject. It is interesting that it was the same Wilks, afterwards Sir Samuel Wilks, who rescued from oblivion Hodgkin's report of certain lymphatic diseases, one of which is now called after him.

Hodgkin's communication[17] was read before the Hunterian Society February 21, 1827, and February 18, 1829, that is with an interval of two years, in the form of two letters to his friend Aston Key, addressed to "My dear Friend," and as they were both members of the Society of Friends, used the "plain language." The first letter begins: "Thou wilt probably

recollect having pointed out to me a few months ago, a particular state of the valves of the aorta, which, by admitting of their falling back towards the ventricle, unfits them for the performance of their function." Hodgkin stated, quite accurately, that "Corvisart, Laennec, Bertin, Rostan, Bouillaud, and Andral had none of them made any allusion to it." He described the condition of the valves, their loose edge considerably stretched and lengthened, "hence when raised and applied to the sides of the vessels, instead of forming a straight or rather concave line, they form a curved one, with its convexity upwards. In some instances there is a manifest laceration of the edge. . . . The structure of the valves is more or less thickened, and the appearance of the corpora Arantii is nearly lost." There are two cases with no clinical details; in another there was "anasarca, irregular heart with impulse tumultuous and strong; some contractions lost at the wrist. The pulsations of the carotid were strong and attended with bruit de scie, which disappeared before death." Post mortem, there was retroversion attended with dilatation and thickening of the left ventricle. In two cases where the pulse is mentioned it was weak in proportion to the heart beat. In the second letter Hodgkin cited the case of Dr. Cox, twenty-eight years old, an athlete. After an attack of syncope following transient mental excitement, there was inordinately violent arterial action, rapid, frequent, and regular. There was a remarkable thrill in the pulse, and the carotids were seen violently beating on both sides. The contractions of the ventricles were strong, and there was a constant bruit de scie, which presented this peculiarity that it was double, attending systole as well as diastole. In another case bounding pulse is mentioned, and in still another, bounding carotids. "The peculiar thrill which was observed in the pulse," Hodgkin said, "might be ascribed to the interruption of the progressive current which must have taken place whenever the elongated valve passed its more healthy fellows, as it was carried from the ventricle into the aorta." He considered excessive muscular effort, or a sudden and violent mental emotion, might be exciting causes for the condition.

There can be no doubt that Hodgkin recognized some of the chief signs of aortic regurgitation, but his mode of presentation, and probably a lack of authority on the part of the periodical in which the letters were printed, prevented him from gaining the recognition he deserved. Wilks[18] returned to the subject in 1878, and pointed out that Corrigan had no better view than Hodgkin of the cause of the murmur, and that it must be presumed his historical association with the disease rests upon his description of the pulse, with its throbbing and its visibility. As he pointed out, Hodgkin knew that bleeding and depletion were bad in aortic regurgitation.

On the whole, the immediate reception of Corrigan's paper was favorable. Graves,[19] in a clinical lecture, presenting a patient with visible pulsation in one arm, said that Corrigan, "in his very ingenious essay" has insisted on leaping of the arteries as a diagnostic sign, but that the symptoms given by him are extremely uncertain, and too hastily established. However, he disclaimed any intention of minimising Corrigan's work, which was ably and well presented.

A more discordant note appears in the work of James Hope, whose book on the "Diseases of the Heart and Great Vessels" forms a landmark in :nedical literature. The first edition appeared in 1831. I quote from the third edition, London, 1839. In a footnote (p. 71), Hope claimed the diseovery of the regurgitations as his wn, made in 1825 in the case of Christian Anderson, and said he ·· taught the regurgitations at St. Bartholomew's Hospital in 1826, and ~~ La Charite, Paris, in 1827." He went on to say that Dr. Corrigan, ··not aware of Dr. Elliotson's pub-.:ication and my own, subsequently published a paper on a new disease the heart, viz., permanent patency of the mouth of the aorta." Speaking of aortic regurgitation (p. 380) he says he described the peculiar pulse in 31, but was in doubt as to its relarion, because in the early cases regurgitation was combined with infiammation of the heart or adhesion of the pericardium. He then said, "Dr. Corrigan who wrote in 1832 or 1833 on permanent patency of the aortic ·alves as a supposed new disease, has so completely overlooked this pulse as even to state the reverse: 'it rises without any jerk under the finger.'" Dr. Hope overlooked the fact that he reference is to a different article from that of 1832 or 1833, but his criticism of Corrigan's description has some foundation. He himself was not accurate in his timing of heart sounds and the case of Christian Anderson is by no means clear as to aortic regurgitation.

A few favorable opinions may be cited. In the translation of Laennec edited by Theophilus Herbert, London, 1846, there is a note by the editor (p. 848), on Andral's comment on valvular insufficiency: "to Dr. Corrigan of Dublin we are in the first instance indebted for a knowledge of this structural anomaly." Dr. Walter Walshe in his "Practical Treatise on the Diseases of the Lungs and Heart," (Philadelphia, 1851, p. 225) says: "Aortic regurgitant disease, as first shown by Dr. Corrigan, renders the pulsation of the superficial vessels visible." Dr. William Stokes, "Diseases of the Heart and Aorta," (Philadelphia, 1855) speaking of aortic regurgitation, says: "We owe the diagnosis of this disease to Dr. Corrigan." Dr. A. Duchek, who wrote the volume on "Diseases of the Heart and Arteries" in the "Handbuch der speciellen Pathologie und Therapie" (Erlangen, 1862, p. 151), says: "We must name Corrigan, who introduced the term insufficience and showed the signs of aortic insufficiency, as the discoverer of this functional anomaly." On p. 187 he gave Corrigan credit for first observing the pulse of unfilled arteries, or the collapsing pulse. Trousseau, in his celebrated "Clinique medicale de l'Hotel Dieu de Paris," 1861–1865 (1: 728), spoke of the "strong and rebounding pulse, with tortuous radial artery, on which Corrigan insisted, and which is of great diagnostic value." He also said aortic regurgitation was called Corrigan's disease. Dr. C. Hilton Fagge, in Reynold's System, 1880, Vol. 2, says: "But it was Sir Dominick Corrigan, who in 1832 first laid stress on the peculiarity of the pulse (in aortic regurgitation), a fact commemorated in the designation of 'Corrigan's pulse,' which is commonly applied to it both on the Continent and in this country." He also quoted the text describing the visible features of the pulse in aortic regurgitation, so that

it has been called "locomotive pulse but also jerking, splashing, or collapsing pulse, or as the water-hammer pulse, from the well known scientific toy of that name." Dr. John F. H. Broadbent, in his book on "Heart Disease" (New York, 1906), said: "This is the well known collapsing or water-hammer pulse, sometimes named after Corrigan, who is believed to have first called attention to it."

I intend to speak more at length of the water-hammer pulse, and think I have shown that to Corrigan the visible changes in the peripheral arteries were most important, and that his *pulse feeling is* very inadequately *described.* Some *early critics pointed* out imperfections regarding details of murmurs, pulse and prognosis. They themselves did not realize in the infancy of physical diagnosis that the complete picture of the disease could rarely be obtained from a small series of cases observed over a short time. They missed the capillary pulse described by Quincke, the uvular pulse of Fr. Mueller, and other details. Even now aortic regurgitation is sometimes overlooked because the patient may be seen when there are no murmurs, and no peculiarities of visible pulse, the pulsus celer being overlooked.

To return to Corrigan's original papers, in 1833[20] we find "A new method of making an early diagnosis of aneurysm of the Abdominal Aorta," with cases well reported.

In 1836,[21] "Observations on Bruit de Cuir Neuf or Leather Creak as a Diagnostic Sign in Abdominal Disease," showing that creak *is* not a *sign* of bydatid cyst *only.* This sign was first described by Collin and investigated by Stokes.

Corrigan[22] wrote again of the "Mechanism of Bruit de Souffiet," an excellent article continuing previous investigations, and again discussing the currents that play a part *in* the production of murmurs.

In the same Journal,[23] he reported "On Aortitis, as one of the Causes of Angina Pectoris; with Observations on its Nature and Treatment." He cited cases of Portal and Bouillaud, and several of his own, recommending treatment by local bleeding, counter-irritation and mercury. This explanation of the cause of angina pectoris, so brilliantly advocated by Sir Clifford Allbutt, was not known to the latter *until* 1908.[24]

An article that added much to Corrigan's reputation[25] was "On Cirrhosis of the Lung," which was read at the Evening Meeting of the College of Physicians, March 19, 1838. The clinical and gross anatomical details show close observation and keen interpretation, but the time was too early for histological investigation. The name was taken from Laennec, the author saying that "this disease is in the lung what cirrhosis is in the liver." Corrigan recognized Laennec's error in taking the liver lobules in the sclerotic tissue for "new structures." He showed the different results in the two organs affected, the shrinking of the liver as contrasted with the dilatation of the bronchi, the displacement of adjacent organs, the simulation of phthisis by the physical signs, and sometimes hemoptysis. He recognized that the process was slow and inflammatory. As to treatment, he was still in the mercury and tartar emetic stage, but *wisely* advised efforts at the development of the sound during

As Corrigan became more and more engaged in practice and public duties, to be mentioned later, his medical

contributions became farther apart; he added no more cardiac details. Occasional items in medical periodicals add to our knowledge of the man.

In the *British Medical Journal*,[26] July 20, 1867, p. 54, there is a letter from the Medical Faculty of the University of Erlangen complaining of the action taken by the General Council of Medical Education and Registration, in the matter of German diplomas, and especially of a speech by Dr. Corrigan (Report of debate, *Brit. M. J.*, June 15, 1867). Sir Dominic made a vigorous reply, pointing out that the reform in the selling of medical diplomas might be abrogated later, and in that case one could get a medical degree for a bill of exchange, just as one could get a cask of Bavarian beer.

In the same year[27] he gave the Address in Medicine before the British Medical Association at the meeting in Dublin, Stokes being President. Corrigan made a vigorous plea for better medical education and referred to German and American diplomas.

Corrigan was born December 1, 1802. He kept up an active life until two years before the end, from hemiplegia, February 1, 1880. Obituary notices in medical and lay journals soon after his death were uniformly laudatory. The article in the Dictionary of National Biography is less so. Although Corrigan did not have the educational advantages of his famous Irish contemporaries, he was probably without an equal among the latter as a master of terse English. Like many Irishmen of the period he was familiar with French; as a Catholic, educated in a Seminary school, he knew Latin, and he quoted Greek at least once in a public address. His knowledge of the physics of the time was sound. He was one of the few men of whom it has been said that he was a classic in his lifetime. One who had been a pupil has recorded that his portrayal of disease had never been excelled for terseness and accuracy. He never lectured more than half an hour at a time, worth noting in these radio days. As a physician he was recognized as the most prominent of his race and religion in Ireland. Reflecting that, his professional income was said to have exceeded that ever received by any other Dublin practitioner. Black-balled when he first sought election to the Irish College of Physicians, he was later elected to Membership, and served five terms as President (1859–1864). He was made Baronet in 1866; was appointed Physician to the Queen in Ireland, and was in Parliament from 1870 to 1874. While he made no great figure there he took his duties seriously. He usually voted with the Liberals, opposed Home Rule, and favored Sunday closing. He represented the Senate of Queen's University of Dublin on the General Medical Council of Great Britian for many years, and was a staunch advocate of better medical education. He was one of the Founders of the Pathological Society of Dublin, and President. An ardent zoologist, he was President of the Royal Zoological Society of Ireland, and while in parliament it was his habit to take the Friday night steamer, so he could take breakfast with the Council on Saturday mornmg.

THE WATER-HAMMER PULSE

I have quoted Fagge and Broadbent on the water-hammer pulse, and from their remarks one can see that they did not attribute the name to Cor-

rigan. This was done, however, by Sir Clifford Allbutt,[28] who said:

> The character of the pulse is well known. The gifted physician to whom we owe ~ost of our knowledge of this subject has grven a memorable description of it. Corngan compared it to the water-hammer, a toy in which water, imprisoned in an exhausted tube, falls, on every turn of the tube, from end to end, with a thud.

When I began to study physical *diagnosis in r882 all* my teachers used the term water-hammer synonymously with Corrigan, and in favorable cases the reason was clear. For before that time a water-hammer was one of the few pieces of apparatus, along with an inclined plane, pulleys, and a balance, available for demonstration in lectures on Physics, and every medical student was familiar with it and recalled the tactile sensations when the instrument was named. When I began to teach physical diagnosis I got a water-hammer and had each student handle it when we had a case of aortic regurgitation. But when many years later, about 1915, I needed another water-hammer I found there were none in stock, and when I had one made to order I found students were not familiar with either the instrument or the feeling produced by its use. This is so now, in my part of the country, and neither teachers nor undergraduates understand what is intended by the allusion, or they think of the "water-hammer" in a steam pipe.

I had read Corrigan's paper early in my teaching days, thought it not as complete as current works. but could not find the water-hammer mentioned. I did not then follow the matter farther, but recently, when preparing for the Corrigan anniversary, I read all of Corrigan's articles' with no more success. Neither in his own articles, nor in those of several of his contemporaries could I find the reference I expected to see. Sir Hufi1;phry Rolleston (personal commurncat1on) tells me that he had a similar experience. I enlisted the cooperation of Dr. William Dock, of Stanford University, who had access to the larger material of Lane Library, but after considerable search, including articles and *case-histories* of *the* time, he could find nothing more. By this time the matter had become very intriguing, and we took It up more systematically. For a long time the earliest use we could find was in an article by A. L. Galabin, M. A., M. o.,[29] "On the Causation of the Water-hammer Pulse, etc." Galabin's words in the text show that neither he nor Corrigan introduced the term. He said:

> I will first refer to a character on which Sir Dominic Corrigan does not lay stress in the article I have quoted, but one which is well known to every one, and which has given to this form of pulse the title which I have taken in the heading of my paper, namely, that of water-hammer pulse. The quality which is well expressed by this name is that of extreme suddenness in the commencement of the pulse, which in marked cases gives to the finger the impression of a sudden blow or jar.

It is not necessary to analyze the paper, which is based on sphygmographic studies, but it may be remarked that even in those early days Galabin knew the tracings were not **always characteristic, u.r1.d that the** "quality of suddenness is only an exaggeration to an extreme degree of a change which takes place to some extent in the normal pulse."

Evidently, other terms than water-hammer must have been used between the time of Corrigan's paper and that of Galabin, or somewhat later. I give a few, gathered from works on Diagnosis or Medicine. Charles Cowan, 1836: Corrigan's visible pulse; Andry, 1843: vibrant; Henry I. Bowditch, 1846: jerking; W. H. Walshe, 1851: hammering; "What to Observe," published under authority of the London Medical Society of Observation, 1855: hammering; A. W. Barclay, 1858: hammering; jerky; thrilling; David Wooster, 1867: hammering; E. J. Woillez, 1879: brusque, vibrating, visible (Corrigan); J. M. Fothergill, 1879: water-hammer; A. M. Corwin, 1879: water-hammer, pistol, collapsing; de Haviland Hall, 1881: visible, locomotive; A. E. Sansom, 1881: locomotive of Sir Dominic Corrigan, Corrigan's or water-hammer, splashing; James Finlayson, 1886: water-hammer, from its sudden slapping or jerking character; the pulse of aortic regurgitation, from its cause; and Corrigan's pulse from its describer. In French and German works Corrigan is sometimes mentioned, but I have not found there the water-hammer. In American and British works after 1900 it is almost always given, with occasion novelties, such as trip-hammer (Tyson, Hare); shotty (Le Fevre).

Finally, William Dock found that G. H. Barlow" in 1852 has said: "this has been termed the splashing or water-hammer pulse," and a possible source in the Lectures of (later, Sir) Thomas Watson.[31] The Lectures were delivered in 1836 and 1837, and repeated for four years; published in the *London Medical Gazette* in 1840–1842, and in book form in 1843. The first Philadelphia edition[32] is dated 1844.

Unlike most of his predecessors, Watson felt that he could generally distinguish the valve affected. Under Aortic Regurgitation he said:

> Moreover, we are again assisted by the pulse. The pulse of aortic regurgitation is, sometimes at least, very striking and peculiar: sudden like the blow of a hammer, without any prolonged swell of an artery. It always reminds me of the well-known chemical toy, formed by including a small quantity of liquid in a glass tube, exhausted of air, and hermetically sealed. On reversing the tube the liquid falls from one end of it to the other with a hard, short knock, as if it were a mass of lead. The sensation given by the pulse, when there is much regurgitation through the aortic valves, is very similar to this. It is as if successive balls of blood were suddenly shot along under the finger. Dr. Hope calls this a jerking pulse; the pulse of unfilled arteries, and this abrupt pulse makes itself visible in the arteries; the wave of blood lifts, and moves, and sometimes contorts the **vessel.**

Watson tells of a case in which the "hard, sudden, hammering pulse" led to the diagnosis. For five years the patient's wife found it uncomfortable to take her husband's arm on account of the jarring blow. Neither Corrigan nor Hope is mentioned in the index of this edition of Watson, but Hope is quoted in the text.

This is the first positive indication we could find of the introduction of the water-hammer in diagnosis, and as the text shows, Watson did not explicitly use the term "water-hammer pulse." That it was not immediately taken up appears from a remark by O. B. Bellingham in the *Dublin Medical Press* of March, 1845: **"Dr.** Watson compares the aortic regurgitation pulse to the blow of a hammer," but not to that of a water-hammer.

In conclusion, "Corrigan pulse" should be applied, if at all, to visible phenomena, "water-hammer" to palpatory sensations. As the handling of water-hammers has been abandoned, the term should also be given up, and simple descriptions used. But the fact that many who disclaim any knowledge of the "chemical toy" of Watson continue to use the words suggests to Dr. William Dock the phonetic parallel between the words "water-hammer" and the palpatory sensations in the pulse, two hard beats clipped off sharply and followed each time by a syllable as weak and flat as the radial artery of such a patient in diastole. If this is so, the term may continue in use notwithstanding my effort to eradicate it, but the user may know he is guided by sentiment.

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