which the muscular arterioles and the vaso-motor nervous system are intimately and obviously concerned has not been without interest even for this learned audience, to whom I desire to offer my cordial thanks for the attentive hearing with which they have favoured me.

ON DR. BILLING'S VALVULAR EXPLANATION OF THE HEART-SOUNDS.

By W. J. LITTLE, M.D.,
Late Senior Physician to the London Hospital, etc.

AMONGST the controversial communications on the causes of the sounds of the heart which have recently appeared in the columns of the BRITISH MEDICAL JOURNAL is one dated September 30th, 1876, from Dr. C. J. B. Williams, in which the following statement occurs:—"I reassert that those observations" (viz., Dr. Williams's experiments on the ass stupefied by woorara) "made in February 1835, supplied the first complete knowledge of the sounds of the heart, which has given to the profession the means of distinguishing the physical signs in health and disease." In the same article, it is said: "My experiments established the view that the *first** sound of the heart is produced by the tightening of the ventricular walls and valves in the systole, and the *second* sound by the tightening of the arterial valves by the recoil on them of the column of blood in the arteries by the diastole"; also: "These observations seem to me sufficiently to prove that the essential cause of the first sound is in the walls of the ventricles." He further adds: "I admit that the auricular valves have their full share with the ventricular walls in producing the systolic sound, and I ascribe the *flapping* commencement of this sound especially to them."

Dr. Williams here appears to lay claim to being the first to demonstrate that the first sound is *in part* caused by the action of the auriculo-ventricular valves, and that the second sound is *wholly* caused by the action of the arterial valves. There is some difficulty in reconciling the apparent meaning of the sentences which I have quoted, when they are compared with each other and with what Dr. Williams wrote in 1835. At that period, he assigned more importance to *bruit musculaire* than he now does, as shown by the following extracts from his work on *Diseases of the Chest*, 3rd edition, 1835, page 175:—"That the first sound is not dependent on the closing of the auriculo-ventricular valves (as imagined by M. Rouanet and others) is evident from Exp. 1, Obs. 4, 6, 7, 8, 9, in which the closure of these valves was partially or completely prevented, yet the first sound still continued.....That the first sound is produced by the muscular contraction itself† may be considered as proved by Obs. 8 and 9 of Exp. 1, in which every other possible source of sound was excluded and the first sound still accompanied the systolic action of the ventricles." There appears also some confusion of language in one of the above extracts, where Dr. Williams speaks of tightening of the valves, and in another place of the *flapping* sound of the valves. Surely Dr. Williams would consider himself somewhat at sea, if he imagined the valves to flap in the blood in the manner that the sail of a ship which is loose at one side flaps about during a gust of wind.

I have waited until the probably approaching end of the controversy, in the hope that some of the contributors to it, and especially Dr. Williams, would have alluded to the labours of Dr. Billing, who, before the date of Dr. Williams's experiments, showed, as the result of anatomical, physiological, acoustic, and clinical research, that the first sound of the heart is produced by *tension* of the auriculo-ventricular valves, and the second sound by the *tension* of the arterial valves. Dr. Williams's experiments were made known in 1835. Dr. Billing's views and explanations were given in his lectures on the *Theory and Practice of Medicine* at the London Hospital during the period of my attendance on those lectures, and whilst I was acting as his clinical clerk in the wards previously to August 1831. I was also present as a visitor at the Hunterian Society in February 1832, when Dr. Billing read a paper on the Valvular Origin of the Sounds of the Heart. This paper was published *in extenso* in the *Lancet* of May 1832. I well remember seeing and hearing Dr. Billing illustrate the mode of production of the heart-sounds by means of a strip of paper held by one hand at each end of it and then suddenly rendering it tense. I refer those readers who desire to investigate the matter to Dr. Billing's *First Principles of Medicine*, 6th edition, 1868, page 37.

Whatever honour may spring from the discovery of the valvular origin of the sounds of the healthy heart—and, in my humble opinion,

this honour is considerable—is due to Dr. Billing, my old teacher, colleague, and friend. I hold that clinical study is a firmer basis of knowledge on this subject than experiments on dying animals, especially when, in addition to removal of the anterior wall of the chest and listening through the stethoscope applied to the naked heart, the operator varies his investigation by "pushing the auricles by the end of a finger into each auriculo-ventricular opening, cutting open the auricle, partially destroying the mitral valve, causing the blood to well out at each pulsation, inserting a hook into the pulmonary artery and drawing back its valves". It is not hereby meant to indicate that any of these methods of inquiry were meaningless or unjustifiable; quite the contrary. Having formerly had some experience in vivisections, knowing the difficulty of carrying them out under circumstances in any way analogous to the normal condition of things, I set a smaller value on the results of Dr. Williams's experiments, confirmatory in a great degree as they are of Dr. Billing's previously published views, than Dr. Williams very naturally places upon them. I express the conviction that Dr. Billing is alone entitled to the merit of the discovery of the sounds of the heart being dependent upon valvular tension.

It is an agreeable thing for the old pupils of Dr. Billing to know that many able later investigators have wholly or partially confirmed his views. Of these may be named Rouanet (September 1832), Bryan (January 1833), Von Kiwisch, Valentin (1850), and Halford (1852). It would seem, from the present controversy in the BRITISH MEDICAL JOURNAL, that the minds of many men are still unsettled as to the presumed existence of coexisting simultaneous causes of sound going on in the heart—movements of fluids, *bruit musculaire*, contact of heart with the walls of the chest, etc. I avoid wearying my readers, and, therefore, refer them to the full sources of information contained in Dr. Billing's book already quoted.

It was a grand merit on the part of Dr. Billing, when so many able men—Hope, Latham, Watson, Clark, Williams, and others, his contemporaries in this country—were, like himself, assiduously employing auscultation, to have alone enunciated and demonstrated the valvular origin of the sounds in 1831, at so early a period after the publication of Laennec's immortal discovery of *Auscultation and Percussion*, and at a period when the facts and explanations of Laennec were undisputed as to this matter by men so gifted as Sir John Forbes, the translator of Laennec's work, and Dr. Thomas Davies, the earliest followers, I believe, of Laennec in this country.

THE RECENT CATASTROPHE AT TYNEWYDD COLLIERY, NEAR PONT-Y-PRIDD.

By H. N. DAVIES, L.R.C.P.L. & ED., Surgeon to the Colliery.

THE subjoined narrative of the recent accident at Tynewydd Colliery is so remarkable in some of its features, especially those having reference to the prolongation and sustentation of life in air considerably compressed, that I have great pleasure in sending it for publication in the BRITISH MEDICAL JOURNAL.

I shall not in this report submit any opinions as to the physiological effects of compressed air on the waste of tissue, or in arresting evaporation, and thus preserving the heat of the body and maintaining the temperature of the cell in which the rescued men were entombed.

It is, perhaps, necessary to remind those of the profession who are unused to colliery operations that, when coal is to be dug, a shaft is sunk to the depth at which the mineral is to be found. From the bottom of this shaft radiate one, two, or three principal roadways; and it is on both sides of these roadways, and at right angles more or less with them, that headings are driven. On each side of these headings, openings are made into the coal, called stalls. Tramways run along the main roads and branch off into each stall. Further, it is to be remarked that, with respect to this and many other collieries in South Wales, the headings run up from the roadways, at a dip or angle more or less acute with the plane of the roadway. It can, therefore, be easily understood that, a mine being flooded, it is possible that, though all practical egress from parts of the interior is closed, the air driven into the upper headings and stalls will ultimately assert its limit of compressibility, and prevent the further advance of the water. This compression will, of course, increase with the weight of the superincumbent water above the level of the remote stalls, to which reference has already been made.

With this imperfect summary of the conditions as to the general structure of the colliery, which I think necessary before the gravity of the facts can be fairly appreciated, I at once come to the stall which en-

* The italics are mine.

† The italics in this paragraph are in the original.

tomed five men, four of whom escaped, whilst one was unfortunately killed.

This stall is known as Thomas Morgan's stall, and is forty-five yards long, thirteen yards wide, and three and a half feet high (the height being the thickness of the coal.) For nine feet of the width a roadway has been cut out of the bottom rock to a depth of two feet, making a total height along it of five and a half feet. This roadway brings the tram from the heading to receive the coal from the gallery whence it is cut. The rise in Morgan's stall from the roadway is one in twelve, and its distance from the bottom of the shaft is nine hundred yards. The cubic capacity of this stall, from which the four men and the boy were rescued, equalled 7,000 feet.

Thomas Morgan, with his two sons, had left the stall, having finished their day's work, at 4 P.M. on Wednesday, April 11th. On their way out, they found a mass of water rolling and surging towards them with an indescribable roar. They succeeded in reaching another stall, where the black waters confined them, and shut out all chance of escape. Here they found two men, who had sought safety from the terrible element below them. In the meantime, four men and a lad had found refuge in the stall left by Morgan and his two sons, as described above.

About six o'clock the same evening, knockings were heard as coming from the stall in which Morgan, his sons, and the two men were immured. The block of coal intervening between the stall and the main heading was twelve yards thick. Men were at once put to work to drive through this column of coal. (It must be remembered that only a portion of the working was flooded.) The difficulty which presented itself was to effect a communication with the men without imperilling the lives of those waiting to be rescued, as well as of those working for their rescue, owing to the compressed air within the stalls. It was determined to bore through the coal. The orifice normally covered a surface two inches in diameter, and it was hoped that the escape of the compressed air through it would so relieve the pressure in the stall as to ensure the working through the block with safety.

I may remark here, that no fear was entertained that the water in the stall would rise high enough in the face to drown the men before they could be released. No sooner was a communication effected, than a tremendous rush of the confined air tore through the hole with an unearthly shriek, carrying with it and hurling in all directions pieces of coal wrenched from the edges of the hole, whilst the terrified miners working in the face were compelled to escape to some place of safety. The men inside were previously warned, through the coal acting as a medium, to keep back from the bore until the pressure was exhausted. Poor Morgan, one of the sons, a young married man with one child, disregarding the admonition in his intense anxiety to get out of his dungeon, was speedily drawn into the adit by the irresistible force of the escaping air, so that his head was as firmly fixed in it as in a vice. Death was instantaneous, and resulted from asphyxia. The skull was not fractured. Other holes were bored, and when the stall was sufficiently relieved, the work of cutting through the coal was resumed. By 10 A.M. on the 12th, the body was removed and the men were liberated.

The next important question was the whereabouts and fate of the other imprisoned colliers, who to the number of nine were known to be in the workings.

On the evening of this day, knockings, somewhat feeble in their intensity, were heard, and were supposed by the sound to have their origin in Morgan's stall, referred to above—a distance of seventy-five yards from the heading. In the then existing conditions of the workings, all hope of reaching the place had to be deferred until the superincumbent water had been substantially reduced.

Into the engineering difficulties and the magnificent skill with which they were surmounted, it is not my province to enter. When measures had so far progressed as to render it a matter of hopefulness that the poor fellows would be rescued, I deemed it necessary to make such special arrangements as to the *locale* to which the imprisoned miners should be brought as would insure the most effective supervision and vigilant attention. With this view, I engaged the large room belonging to the Tynnewydd Inn closely adjoining the colliery, and had it fitted up as a hospital, with the most humane and skilful local nurses in attendance. Everything above ground being ready, I left the surface arrangements in charge of my friend Dr. E. W. S. Davies of Mountain Ash, and of my brother Mr. Idris Davies of Ystrad. It was determined, however, to utilise a shed near the pit's mouth as a temporary relief station for the rescued men, if it were found that they were too weak to be carried to the hospital.

I and my assistants, Messrs. Dukes and W. Davies, had been in the pit forty-eight hours in attendance, with a few intermissions, in consequence of the frequent and harassing rumours that our services were immediately required. My object was to be in readiness to afford the

necessary assistance, without a moment's loss of time, to men who had now been immured two hundred and fourteen hours.

On Friday, April 21st, the crisis, in so far as the rescue of the men was concerned, was over.

Condition of Men when Released.—1. David Hughes, the boy, was the first to be released. He was carried from the stall through the tunnel that had been made in the coal to reach it, on a stretcher. He was perfectly sensible. The general surface of the body was warm; pulse 84. He complained of a little weakness only. His voice was natural in tone; the breathing quiet, but a little hurried. Four ounces of warm milk and gruel were given, and were taken with apparent relish.

2. John Thomas was brought through the tunnel on a stretcher. He was extremely weak, and much emaciated; pulse very rapid and small. He was perfectly conscious. The feet and lower limbs were cold; his breathing was hurried. The surface of the face and trunk was warm. His voice was very weak. Six ounces of milk and gruel were administered, and appeared to be taken readily. Bottles containing hot water were applied to his feet. Having been wrapped in blankets, he was sent to the surface. On his way to the bottom of the shaft, the distance between which and the mouth of the tunnel is, as I have previously stated, nine hundred yards, another bowl of milk and gruel was given him, which he took without difficulty. Before the bottom of the shaft was reached, he had greatly revived.

3. George Jenkins, the next collier rescued, walked from the stall through the tunnel, a distance of thirty-eight yards, the height being three feet and a half. On reaching the main heading, he was found to be perfectly sensible, and talked readily; pulse 80, full, but compressible. The general surface of the body was warm; the feet and legs were wet. His voice was strong. He was unwilling to be placed on a stretcher, but readily submitted. His boots and stockings were removed, and he was carried to the bottom of the shaft.

4. Moses Powell also walked through the tunnel. He was perfectly conscious; pulse 90, small and compressible. He talked freely.

5. David Jenkins was the last to leave the stall, brought through the tunnel on a stretcher. He was quite conscious, calm, and collected. He spoke readily but feebly. The pulse was 95, small and compressible. The general surface of his body was warm. To each, the same quantity of milk and gruel was administered; and, enfolded in warm blankets, they were brought to the surface.

And here I must perforce discharge one duty. In all the underground arrangements for securing the necessary comfort and attention for the men as they were brought out, I have to express my deep sense of gratefulness to Dr. E. Lloyd of Castella, near Pont-y-pridd, Messrs. Rees Hopkins of Pont-y-pridd, Ivor Lewis of Llantrisant, T. Parry of Ferndale, as well as to my assistants, Messrs. Dukes, C. Jones, W. Davies, and P. James, for their exceedingly valuable assistance, by which my efforts were supplemented.

Treatment on Surface.—When the surface of the pit was reached, the men were one by one carried to the temporary shed improvised for their reception, where Dr. E. W. S. Davies and his colleague at once saw them; and they were placed as comfortably as the limited facilities of the structure would permit. More milk and gruel, with occasionally a little coffee, was given to the men, who experienced no difficulty or inconvenience whatever in taking the food offered to them. At the expiration of an hour and a half, it was deemed desirable to remove the patients to the hospital prepared for them, which they reached a few minutes later, and where they were placed in warm comfortable beds.

General Conditions.—Taking the cases, the following indicia applied to them as a whole. There was much emaciation, but not so extensive as might have been expected; with the exception of John Thomas, whose abdomen, in addition to being flat and tympanitic in common with those of his fellow sufferers, was hollow. The men were perfectly conscious. There was an entire absence of nervous excitement. No eagerness or avidity was manifested by any for food or drink, which, when taken, was taken readily, and attended with no inconvenience. The tongue was tremulous, coated in the middle, and red at tip; the papillæ were considerably enlarged, and retained the impression of the teeth. The conjunctivæ presented a jaundiced appearance. The breathing was quiet; the breath was fetid, especially that of J. Thomas and D. Jenkins. Contact with light produced uneasiness to J. Thomas more than to the others.

Condition in Stall prior to Rescue.—Each was wet the first day, and all complained of chill during the whole time they were immured from their damp clothes, which never became dry. Heat was kept up by exercise, by cutting coal or wood, or by rubbing themselves. To sustain heat, they lay huddled together in a tram half filled with coal-dust;

and, through the non-conductive power of coal, they succeeded. The men had lighted candles up to within two days of their deliverance. Sleep was irregular and disturbed. Water was swallowed in large quantities.

Tabulated Results of Detailed Observations.

At Pit's Mouth.	Temp.	Pulse.	Resp.	Regimen, etc.
Friday, 5 P.M.				
John Thomas (a)	96.1	84	24	Coffee, beef-tea, milk, and strong soup
David Hughes (b)	97.1	84	16	
Moses Powell (c)	98	96	28	
George Jenkins.	96	84	20	
D. Jenkins (d) ..	98	96	21	
Saturday (noon)				
J. Thomas (e) ..	98.4	80		Ditto. All were free from pain
D. Hughes	98.4	72		
M. Powell	98.8	80		
G. Jenkins (f) ..	99.1	60		
D. Jenkins	98.5	60		
Sunday, 6 A.M.				
J. Thomas	97	98		Ditto. ditto
D. Hughes	98.2	82		
M. Powell	98	72		
G. Jenkins	98.3	70		
D. Jenkins	98.1	56		
Sunday (noon).				
J. Thomas	98.2	105		Ditto. ditto
D. Hughes	98.2	72		
M. Powell	96.2	72		
G. Jenkins	98	68		
D. Jenkins	97.2	56		
Sunday, 11 P.M.				
J. Thomas	98.3	92		Beef-tea, except J. Thomas—milk and gruel
D. Hughes	97.2	74		
M. Powell	96.2	72		
G. Jenkins	98.1	66		
D. Jenkins	97	58		
Monday, 6 A.M.				
J. Thomas	97.2	82		All spent a good night. Tongues very much improved. Dinner—beef-steaks and potatoes; tea—coffee, with eggs mixed, bread and butter; supper—gruel
D. Hughes	97.3	74		
M. Powell	96.3	76		
G. Jenkins	97.3	66		
D. Jenkins	97.1	56		
Tuesday, 6 A.M.				
J. Thomas	97.4	84		Good night: all complained of pains in feet. 8 A.M., breakfast—milk & bread; 12 (noon), luncheon—beef-tea; 4 P.M., dinner—beef, potatoes, and greens; 7 P.M., tea; 9.30 P.M., supper—half-pint of gruel
D. Hughes	97.3	72		
M. Powell (g) ..	96.3	70		
G. Jenkins	98	62		
D. Jenkins	97.2	56		
Wednesday, 6 A.M.				
J. Thomas (h) ..	97.2	56		Milk and gruel diet. Half an ounce of castor-oil for each; and belladonna liniment to be rubbed well into the feet
D. Hughes (i) ..	96.4	76		
M. Powell	98	78		
G. Jenkins	98.2	72		
D. Jenkins	97.2	68		
Thursday, 6 A.M.				
J. Thomas	98.2	70		Bowels of all freely opened; feet scarcely so tender; tongue cleaning; appetite improving; strength increasing. Breakfast—bread and milk; lunch—beef-tea, one pint; dinner—mutton-broth, one pint; tea—tea, bread and butter, supper—gruel
D. Hughes	96.3	56		
M. Powell	97.2	70		
G. Jenkins	97	66		
D. Jenkins	96.2	62		
Friday, 6 A.M.				
J. Thomas	97.3	72		Good night; bowels free; feet better, except Powell and G. Jenkins
D. Hughes	98.1	86		
M. Powell	97.2	62		
G. Jenkins	93	88		
D. Jenkins	96.3	68		
Saturday, 6 A.M.				
J. Thomas	97.3	72		Powell and G. Jenkins very restless night, owing to pain in feet; no swelling; neuralgic pains; bowels open, except Powell. Up and dressed to breakfast on my visit at 9 A.M.—R. Lin. bellad. ʒiij; lin chlorf. ʒi. Fiat linimentum. To be rubbed in well.—R. Pilulæ hydrarg. gr. ii; pulv. ipecac. gr. i; pilulæ rhei co. gr. ij. Fiat pilulæ. One every night for each
D. Hughes	97.1	82		
M. Powell	97.3	68		
G. Jenkins	97.3	64		
D. Jenkins	96.4	68		

a. At 10.30 P.M., passed four ounces of urine, highly charged with lithates; no albumen. I had intended to make a more exhaustive analysis, to ascertain specific gravity, amount of urea, etc.; but unfortunately my instructions not to remove the urine were forgotten by the nurses in charge.

b. Bowels relieved; eight ounces of black and shaped fæces.

c. Passed ten ounces of urine, highly charged with lithates; no albumen. Bowels relieved; eight ounces of black and shaped fæces.

d. Passed ten ounces of urine, highly charged with lithates; no albumen.

e. Bowels acted for the first time about midnight; fæces about eight ounces, dark, not shaped.

f. Bowels acted about 1 A.M.; fæces eight ounces, dark and shaped.

g. Bowels open for the first time since liberation.

h. Bowels confined.

i. Had a very restless night.

J. Thomas, however, drank but little. The bowels of the men were relieved on Wednesday, April 11th, and only once afterwards during their incarceration. J. Thomas, however, suffered from diarrhoea. Urine was passed frequently, and in small quantities, accompanied at the latter period of their confinement with a very fetid odour, which made the spot used as an urinal very disagreeable. The feeling of thirst increased as that of hunger diminished. J. Thomas became restless and delirious, and with difficulty could be restrained. D. Jenkins also became delirious towards the end of the period. A general tendency to drowsiness appeared to seize the men. D. Jenkins was the only one who took a portion of the candle, which he did in the form of pills. The rest could not get beyond the first stage of tasting it. When the water advanced in the stall on the morning of the rescue, all except G. Jenkins and Moses Powell retreated to a small hole in the face of the workings and above the reach of the water. The necessity of communicating with the rescuers compelled these two men, as the strongest, to stand or rather bend in the water, which had risen to their knees. All suffered more or less from neuralgic pains in their feet, especially the two mentioned. It should be remembered that these men were cooped up in a cavern only three feet and a half high, and with a floor damp from constant water-droppings. In the case of Jenkins and Powell, who so generously and heroically allowed their companions to retreat to a place of comparative safety, each was bending in this cave of Stygian darkness with nine inches of water around them, which they believed to be gradually rising only to drown them inch by inch before effective help could save them. In this view, the pains in the feet are explicable.

Notwithstanding the imminence of death, each was hopeful that he would be permitted to see the light and feel the air of Heaven again. Considering the adverse conditions, which are almost too painfully horrible in their ghastly grimness to be realised, it is extraordinary that the poor fellows, who are now on the fair road to convalescence, could have battled with their fears, with deprivation of food, and with constant chill in an atmosphere of 25 lbs. to the inch above the normal pressure, for two hundred and fourteen hours so successfully as they appear to have done.

Particulars as to Condition of Health previously to Accident.—On the morning of the accident, each took for breakfast bread, butter, and tea; and with him, for luncheon, half a pound of bread with cheese.

Moses Powell, aged 30, single, lives with his mother. His height is 5 feet 6¼ inches; weight, 140 lbs. He is dark, of a phlegmatic temperament; has always enjoyed good health; does not remember having had a day's illness. He is intemperate.

George Jenkins, aged 32, widower; height, 5 feet 5¼ inches; weight, 160 lbs. He is light, of a quick temperament. His health has been good, except that about eleven years ago he was subject to fits, which lasted for three years. He is very temperate.

David Jenkins, aged 40, married; height, 5 feet 4¾ inches; weight, 130 lbs. He is dark, of a rather nervous temperament. He has had a dry troublesome cough for about three years. His health has been generally good. He is very temperate.

John Thomas, aged 26, single; height, 5 feet 8 inches. He is fair, of a decidedly sanguineous temperament. He has had no serious illness. He is the son of scrofulous parents, is very deaf, and has an impediment in his speech. He is quiet and steady.

David Hughes, aged 16; height, 5 feet 1¾ inches; very slight. He has had scarlet fever and measles. He is a delicate boy, subject to cough and shortness of breath. He was in his usual health on the morning of the accident.

The men are now able to get about and dress, and are rapidly becoming convalescent. The pains in the feet are much relieved, though still a source of inconvenience to Powell and Jenkins. There is no indication of cough, or difficulty of breathing, or pain in the chest, in any of the invalids.

All have gone to their respective homes.

A FORM OF BURSAL ENLARGEMENT.*

By A. W. MAYO ROBSON, L.R.C.P.Lond., M.R.C.S.,
Demonstrator of Anatomy at Leeds School of Medicine.

THE cases concerning which I purpose making a few remarks are one of subacute and another of acute inflammation of the bursa situated beneath the ligamentum patellæ. That they are of great rarity I do not for a moment consider, since within a few weeks two such cases have come under my personal observation; but, as I cannot find an account of any similar ones in the ordinary surgical works, I con-

* Read before the Leeds and West Riding Medico-Chirurgical Society.