cedema of the legs was entirely gone. He passed urine in the pre-scribing-room; and repeated examination by my clerks and myself showed that the albumen had quite disappeared. The patient has not attended since, from which I infer that he continues well. He had presented himself regularly at the hospital the previous three months, and the urine was regularly examined. The albumen was observed to be slowly diminishing in quantity, but it had never been absent from the secretion. It appeared, in this case, that the kidneys had received a sudden impulse to healthy action.

In another case, that of John B., aged 25, who had been under my care for two years continuously for acute, passing into chronic albuminuria, the albumen, which had long been stationary, began to decrease rapidly in amount under the influence of the same treatment.

The effect of a powerful dose of atropia upon the kidneys in chronic albuminuria is well seen in the analyses above given. It will be observed that there was a decided diminution of the albumen during the operation of the medicine. The result by the operation of belladonna in these cases must be accepted as the best proof of the condition of the blood-vessels generally during that operation. It is quite clear that there is no impediment from contraction of the arteries on the one hand, or from dilatation of the capillaries on the other, to the flow of blood through the kidney. On the contrary, it appears that the vessels of the gland are aroused by the action of the drug into a healthy state of excitement; a condition highly favourable for the nutrition of the organ, and the removal of chronic disease. As a means of promoting oxidation of the blood, belladonna will doubtless prove of essential service in the uric and lactic acid diatheses. I have employed it in rheumatic fever with marked success. I inject the fiftieth or fortieth of a grain of the atropia salt into the integument over the affected joint, as soon as the first indication of inflammatory action arises in the part. The anodyne action is so direct, speedy, and enduring, that the use of opium, which, excepting for its anodyne and hypnotic actions, is decidedly objectionable in this disease, is altogether unnecessary. The subcutaneous use of atropia in other acute diseases is a wide field for inquiry, and promises, as far as my observations extend, to be a most interesting and encouraging one.

FURTHER OBSERVATIONS ON THE CÆSAREAN SECTION.

By THOMAS RADFORD, M.D., F.R.C.P.Ed.,
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INFANTILE MORTALITY.—Infants *in utero* may die during pregnancy from disease within their own bodies, or from any morbid cause existing in the placenta or funis which can interrupt the supply of blood from the maternal system. Undue protraction of labour is extremely hazardous to the lives of infants, and especially so after the discharge of the liquor amnii. The five infants which are stated to have been dead were so before the performance of the operation. Of this number, two were doubtless destroyed by long continued pressure during protracted labour. One presented with the arm, for the delivery of which manual and instrumental attempts had been unsuccessfully made. One presented with the feet, in which case, after drawing down the body, craniotomy was performed; and afterwards the body was dragged away by the feet, leaving the perforated head behind. In another, craniotomy was unsuccessfully performed. It is quite evident from the above statement, that there is not a single infantile death which was caused, either directly or indirectly, by the operation; and there is little doubt that all of them would have been saved, if they had been living at the time of its performance.

OPERATION.—I shall not here enter into all the details which are requisite to be observed before, during, and after this operation; but I shall confine my remarks to some of the more important points. (See observations, *BRITISH MEDICAL JOURNAL*, vol. i, 1865, p. 263.)

Frequent examinations *per vaginam* are extremely injurious, from the contusions which the vagina and pelvic tissues sustain. There are cases recorded which forcibly prove the necessity of this precaution. When the uterus is deflected, as it generally is in cases in which there is extreme distortion of the pelvis from mollities ossium, this organ must be raised up before the incision is made; so that the fundus, which abounds with large anastomosing veins, may not be incised. Neglect of this rule doubtless would produce hæmorrhage by the division of this portion of the uterus, which is so vascular and eminently contractile, and consequently would interrupt the efficient contraction of

the organ, which is so important to produce a nice adaptation of the edges of the wound, and thereby, in some measure at least, to prevent it from assuming the gaping character which occurred in some of the tabulated cases.

Labour unduly protracted, from any cause whatever, is nearly always attended or followed by some danger to either the mother or to her infant, or to both. The degree of mischief inflicted on the maternal structures is in general in a ratio proportioned to the period of protraction; and, doubtless, in all cases it is aggravated by the nature of the obstructing cause. We ought, therefore, to be extremely watchful, in all cases of protracted labour, but especially so when the impediment arises from a mechanical cause; and we should timely adopt appropriate measures for the delivery of the woman before irreparable mischief is done. (See former observations, *BRITISH MEDICAL JOURNAL*; also Cases of Laceration of the Uterus, etc., *Obstetrical Transactions*, London, vol. viii, p. 210.)

In ordinary labours, where the infant can pass *per vias naturales*, certain organic changes are waited for; the os uteri must be more or less dilated; but, in those cases which demand the Cæsarean section, it is not only a very great folly to wait, as dilatation cannot be effected, but it is a very great evil.

An early performance of the operation is of the utmost importance. Supposing the woman at full term of pregnancy, it should be commenced as soon as the labour is declared—before, or at least immediately after, the membranes are ruptured. By so doing, the uterine incision would be relatively considerably diminished after the complete contraction of the uterus, and all the dangers of protraction avoided. My friend Dr. Greenhalgh has suggested the performance of this operation before the completion of pregnancy. He says: "I have a strong conviction that greater success would attend our endeavours if all cases were operated upon at, or shortly after the completion of, the eighth month of utero-gestation, when the vessels are smaller, the contractile power of the uterus greater, and the liquor amnii relatively larger in proportion to the size of the child. By pursuing such a course, a smaller incision would be required, less blood would be lost." I am inclined to agree with the above suggestion, especially if the obstructing cause of labour be epithelioma of the os or cervix uteri. Two successful cases are recorded (p. 14) in which the operation was performed before the completion of pregnancy—one at the end of the eighth month, by Dr. Greenhalgh; the other at six and a half to seven months, by Dr. Newman. There is, however, one objection, either real or imaginary, against having recourse to the operation before the completion of pregnancy, when the os uteri is closed by the mucous plug, and the cervix is undeveloped; which condition would tend to prevent the lochial or other fluids from issuing from the cavity of the uterus. In consequence of this opposition, the fluid would accumulate up to a certain amount, and then be discharged into the abdominal cavity. Such an event happened (closing of os and cervix uteri) on the second day after the operation in Case 95. Care must, however, be taken to keep open, if possible, the oral and cervical portion of the organ by some means or other.

Before the incision is made, it is of great importance to ascertain the location of the placenta. Its position in sixteen cases was as follows. In eight, it was placed anteriorly; in seven of which it was central, in one a little to the left. In eight cases, it was fixed on the posterior part of the uterus; in three of which it was centrally situated; in two, it was towards the fundus; in one, to the left; and in two, to the right side.

During the operations, the placenta was unfortunately cut in two cases; it was partially separated in four cases; and in two cases it was completely detached and removed before the extraction of the infant, which is most hazardous to the mother (see remarks on Hæmorrhage), and also to the infant. In order to avoid as far as possible cutting the placenta, the stethoscope ought to be used; and doubtless, in the great majority of cases, satisfactory information, either negative or positive, will be obtained. If the "placental soufflet" is not heard, the infant being still alive, it is fair to conclude that this organ is not within the reach of the knife. If the infant is dead, there is not much risk of cutting into the placenta.

In sixteen cases, the incision was made longitudinally in the centre along the linea alba; in three cases, it was made a little to the left of it. I prefer the left side, at a little distance from the linea alba.

It is of the greatest importance that the operation should be completed as expeditiously as possible, in order to avoid the hazard of inducing rapid and irregular contraction of the uterus before the incision is made sufficiently long, so as to safely extract the infant. It is of great consequence not to have again to incise the organ when the infant's body is in a great measure brought out. This has happened. In Case 96, the uterine tissue was torn, in consequence of the incision being too small; it was only four inches long.

* Concluded from page 297 of last number.

TABLE OF CASES OF CÆSAREAN SECTION IN GREAT BRITAIN AND IRELAND.

No	Year.	Name and residence of the patient.	By whom and where the case is related.	Operator.	Cause of the difficulty.	Duration of the labour.	Mother.		Child.		Mother survived.
							Preservd.	Died.	Preservd.	Died.	
78	Aug. 29, 1837.	Frances M., aged 38, Lambeth Workhouse.	Mr. T. Bryant, <i>Obs. Trans.</i> , vol. vi, p. 197; London.	The late Mr. T. E. Bryant.	Distorted pelvis from rickets.	66 hours; 18 hours after rupture of membranes.		D.	P.		31 hrs.
79	April 27, 1863.	Mrs. S., aged 21 years.	Dr. M. T. Sadler, <i>Edin. Med. Jour.</i> , vol. 10, page 268; <i>Medical Times and Gazette</i> , vol. ii, p. 141; 1864.	Dr. M. T. Sadler.	Supposed to be exostosis; found after death to be an enormous cyst filled with hydatids, which was rendered so hard as to represent a bony growth.	Some days in lingering labour; membranes ruptured 8 days before operation.		D.		D. §	Rather more than 24 hrs.
80	July 31, 1864.	J. G., aged 31 years, Westminster Hospital.	Dr. Frederic Bird, private communication to the writer.	Dr. F. Bird.	Dwarf 3 feet 10 inches high; distorted pelvis; antero-posterior diameter, 1½ inches.	72 hours before operation; 48 hours before the rupture of the membranes and 24 after.		D.		D.	15 hrs.
81	January, 1865.	A poor woman; as she resided in a miserable room she was removed to the Lying-in Hospital, Belfast	Dr. Pirrie, <i>BRITISH MED. JOUR.</i> , vol. i, p. 94, 1865. Dr. Pirrie kindly furnished me with notes.	Dr. Pirrie.	—	Had been four nights and days in labour before she came into the hospital.		D.	P.		About 20 hrs.
82	1865.	—	Dr. Wiblin, <i>BRITISH MEDICAL JOUR.</i> , vol. xi, page 261, 1865.	Dr. Wiblin.	Deformed pelvis.	—		D.	*	*	25 hrs.
83	Oct. 15, 1865.	Mrs. —, an Irishwoman.	Sir J. Y. Simpson, <i>Edin. Med. Jour.</i> , vol. xi, page 865.	Supposed Sir J. Y. Simpson, Bart.	Deformed pelvis; found the promontory of sacrum projecting greatly forwards like the size of a closed fist.	Liquor amnii discharged, as far as I can calculate, about 96 hrs. before the operation; had slight pains several days; os uteri dilated to nearly full size many hours before operation.		D.		D. §	67 hrs.
84	Sept. 27, 1865.	Mrs. L., aged 28 years.	Dr. Greenhalgh, <i>Obs. Trans.</i> , vol. vii, p. 220; also an abstract of case <i>BRIT. MED. JOUR.</i> , vol. ii, 1867, case vi, p. 400.	Dr. Greenhalgh.	Distorted pelvis from rickets.	About 28 hours; membranes ruptured and liquor amni discharged 28 hours, or thereabouts.		D.		D. ¶	31 hrs.
85	Nov. 11, 1865.	Mrs. W., aged 32 years.	Dr. Greenhalgh, <i>Obs. Trans.</i> , vol. vii, p. 275; also an abstract of case <i>BRIT. MED. JOUR.</i> , vol. ii, 1867, case vii, p. 400.	Dr. Greenhalgh.	Distorted pelvis from mollities ossium.	As far as I can compute, about 112 hours, or nearly 5 days; liquor amnii discharged about 24 hours.		D.		D. §	80 hrs.
86	1865.	E. B., aged 34 years, Middlesex Hospital, London.	Editor of <i>Lancet</i> , <i>Mirror of Practice of Med. and Surg.</i> , vol. ii, pp. 700 and 722, 1865, under the care of Dr. Hall Davis.	Mr. De Morgan.	A cancerous growth from os uteri and vagina.	The membranes were ruptured; liquor amnii discharged 10 days before operation. Strong bearing pains set in perhaps 2, 3, or more hours before its performance, but slighter uterine pain may have existed before.		D.	P.		About 40 hrs.
87	Feb. 3, 1866.	M. G., aged 30, St. Bartholomew's Hospital.	Dr. Greenhalgh, <i>BRIT. MED. JOUR.</i> , vol. ii, 1867, case viii, p. 491.	Dr. Greenhalgh.	A large epitheliomatous growth of the cervix uteri.	About 5 or 6 hours; membranes entire.		D.	P.		69 hrs.
88	Jan. 23, 1866.	Ellen O., aged 27 years, Cottessmore, Rutland.	Dr. W. Newman, <i>Obs. Trans.</i> , vol. viii, p. 343, London.	Dr. W. Newman.	Extensive epithelioma of the cervix and lower part of the body of the uterus.	4 days; the liquor amnii discharged two days before the operation.	P.		P. †		Recovered.
89	Mar. 29, 1866.	Sarah W., aged 37 years, St. Bartholomew's Hospital.	Dr. Richardson, <i>Med. Times and Gaz.</i> , vol. i, 1866, p. 362; Dr. Greenhalgh's patient, <i>BRIT. MED. JOUR.</i> , vol. 2, 1867, p. 491, case ix.	Dr. Greenhalgh.	Epithelioma of the cervix uteri.	Labour had not commenced, and the membranes had not ruptured.	P.		P. †		Recovered.
90	May 27, 1866.	— Barnes, aged 38 years, Westminster Hospital.	Dr. Frederic Bird, in a private communication to the writer.	Dr. F. Bird.	A large fibrous tumour impacted in the pelvis.	10 hours before the operation was performed, the liq. amnii having just escaped.		D.	P.		33 hrs.
91	June 14, 1866.	A woman, a patient of the Lying-in Hospital, Liverpool.	Liverpool correspondent of the <i>BRIT. MED. JOUR.</i> , vol. i, 1866, p. 673.	Dr. Grimsdale.	High distortion of the pelvis from disease of the spine and ankylosis of the right hip. The conjugate diameter did not exceed 1½ inch.	—	P.		P.		

* No account. † Premature, up to 7 months; born alive. ‡ Lived an hour. § Dead before operation. ¶ Head perforated before admission. ¶ Dead before from craniotomy.

Table of Cases of Cæsarean Section (concluded).

No.	Year.	Name and residence of the patient.	By whom and where the case is related.	Operator.	Cause of the difficulty.	Duration of the labour.	Mother.		Child.		Mother survived.
							Presrvd.	Died.	Presrvd.	Died.	
92	Aug. 19, 1866.	Mrs. W., aged 29 years, Shoreham.	Dr. Greenhalgh, <i>Lancet</i> , vol. ii, p. 203, 1866; <i>BRIT. MED. JOUR.</i> , vol. ii, 1867, p. 491, case x.	Dr. Greenhalgh.	A cancerous tumour of the rectum; solid and immoveable; of such a size that in no part of the pelvis could more than the index-finger be passed.	Not in labour; eight months and a week advanced in pregnancy.		D.	P.		6 days.
93	June 3, 1867.	Ann Kinsey, aged 21 years, Northern Etchells, Cheshire, brought to St. Mary's Hospital, Manchester.	Dr. D. L. Roberts. Read at the Obstetrical Society, Dec. 4, 1867. Abstract of case, <i>Lancet</i> , vol. ii, page 769, 1867.	Dr. D. L. Roberts.	Deformity of the pelvis from an undeveloped state of the bones and malformation of the apertures.	The exact duration of the labour is a little uncertain; but, as far as it can be computed, it was fully 48 hours. The liquor amnii had been discharged for a considerable time; it may from 30 to 40 hours.		D.	P.		4 days 15 hrs.
94	Oct. 6, 1867.	Martha Baggot, aged 21 years, 28, Stafford St., Lisson Grove, British Lying-in Hospital, Lond.	Dr. Eastlake, <i>BRIT. MED. JOUR.</i> , vol. ii, p. 314, 1867. Further particulars, private communication made to the writer.	Dr. Eastlake	Distorted pelvis from rickets.	96 hours; viz., 48 before, and 48 after, the rupture of the membranes.		D.	P.		4 days.
95	Oct. 25, 1867.	Informed she was about 24 yrs. of age; Guy's Hospital.	Dr. J. Braxton Hicks, private communication to the writer.	Dr. J. B. Hicks.	Distorted pelvis rostrated, from softening of the bones about puberty for eight months only.	Operation performed at 8½ months of pregnancy, inducing uterine pains by secale a few hours previously.		D.	P.		4 days.
	Dec. 28, 1867.	Mrs. H., 23 yrs. of age, Pickering Place; removed to the London Surgical Home.	Dr. John Taylor, <i>Lancet</i> , vol. i, 1868, p. 85. Further particulars communicated to the writer.	Mr. Baker Brown.	Pelvis distorted from an exostosis springing from the sacrum. The whole internal surface of this bone is thickened by bony deposit, which is greatly and suddenly increased at its promontory, reducing the ant. posterior diam. to 1½ inch. The deformity is increased by the extreme angular position of the pelvis in relation to the spine.	18 hours; membranes not ruptured.	P.		P.		Lived.

SUTURES.—The edges of the uterine wound have been brought together by sutures in three of the cases. In two, there was considerable hæmorrhage; and in them this practice was adopted to restrain the bleeding, and to bring together the edges, which were gaping. In one, iron wire was used; in the other, common ligature. In the third, the interrupted suture was employed. These women died. Although I am not disposed to attribute their deaths to the application of the ligatures, yet I am strongly of opinion that sutures ought not to be introduced into the uterine walls; and, indeed, I think that they would prove, in general, not only useless, but, by the uterine tissue yielding, they would be injurious. Since the above was written, a case of recovery after Cæsarean section (96) has occurred, in which the edges of the uterine wound were brought together by eight silver sutures, which were left in the uterus. The abdominal wound was also closed by silver sutures.

CHLOROFORM.—Chloroform is nearly always administered in capital or important operations, for the purposes of inducing a state of quietude in the patient, of diminishing the pain inflicted by the knife, and of lessening nervous shock. To attain these ends, it is most important and valuable. In most operations, there are few objections to be raised against its administration; but in Cæsarean cases it is otherwise. For the success of the operation, it is essential to obtain a full, complete, and energetic contraction of the uterus. This organic condition secures against hæmorrhage, and, both immediately and remotely, not only lessens the size of the wound, but also contributes to a nice and firm adaptation of its edges. Therefore, every method should be adopted to aid this organic state; and everything ought to be avoided which interferes with it or lessens it in the least degree. Chloroform diminishes the energy of the uterus, and induces relaxation; and, therefore, on this ground, its administration is here contraindicated. Its anæsthetic agency in subduing pain is not to be compared to the dangers which may ensue. I have never known the moral courage of women fail, and have always found that they have endured the operation with great fortitude. A common expression has been, that they have suffered less pain during the operation than they have had from one unavailing labour-pain. Vomiting has taken place in most of the cases in which chloroform had been administered. It has varied in degree. In some cases it has been very

urgent and continued. In Case 96, it was incessant until the fourth day; the abdominal wound was burst open; a knuckle of intestine was protruded; and fresh sutures were required. Chloroform was inhaled in ten cases; vomiting followed in nine. Whether this effect is to be considered as a *propter hoc* or a *post hoc*, some may doubt; but I am disposed to consider it as the first. At all events, the effect of vomiting after this operation is most hazardous. Dr. Kidd endeavours to trace vomiting after chloroform to other causes. (See his remark, *Edin. Med. Jour.*, January 1868, p. 596.)

ETHER-SPRAY.—The profession are greatly indebted to Dr. Richardson for the introduction of ether-spray as a local anæsthetic. This mode of subduing pain inflicted by the knife has been employed in four Cæsarean cases, and doubtless it is a most valuable agent. It has been remarked, that it not only completely subdues sensibility, but it also promotes energetic contraction of the uterus. In all the four cases, the abdominal parietes were completely æsthetised; but, in two only, as far as I can ascertain, was the ether-spray played upon the uterus. In both these cases, strong uterine action was induced, which seized and firmly embraced the bodies of the infants, and thereby rendered their extraction difficult. In one of these cases, "the uterus contracted so firmly as for a short time to impede the introduction of the hand into its cavity." Uterine contraction after the removal of the infant and the placenta is the most effective security against the dangers of hæmorrhage, etc.; but, if it be inordinate in degree and prematurely induced, it then becomes mischievous and dangerous to the life of the infant, by firmly grasping it, and rendering its withdrawal extremely difficult. There is also some risk of the uterine tissue being lacerated, as the length of the wound becomes comparatively so much diminished by the contraction of the womb. In one of the cases (93) at which I was present, the uterine tissue appeared to be hardened, and thereby rendered less fit for a nice adaptation of the edges of the wound. They presented a gaping character, which was very conspicuous after death. Serious reflection on the effects of ether-spray which I witnessed in this case (93), and also on those reported to have happened in the other cases, has convinced me that the application of the anæsthetic agent should be solely confined in Cæsarean cases to the abdominal parietes. I agree with Dr. Roberts,

that the uterus should not be subjected to its influence, because I feel certain that there is less mischief to be apprehended from the pain inflicted by incising the organ, than what is likely to accrue from the playing of the ether-spray on the part when the abdomen is laid open. I do not apprehend that the edges of the abdominal wound are likely to suffer in the way. Dr. Kidd (*loc. cit.*) states that the lips of the abdominal wound after ovariectomy may mortify; he says, "under ether-spray the lips of the wound, too, may mortify."

In conclusion, I think I may fairly state that, although the maternal statistics of this operation present an unfavourable aspect, I am fully warranted, after a full and candid investigation of the causes of the death of the mothers, in concluding that they are not, in most of the cases, to be attributed to the operation. Some of these causes are avoidable, or preventable; some are controllable.

My opinion as to making the Cæsarean operation conditionally one of election remains unchanged.

THERMAL VALUE OF FOOD.*

By WILLIAM H. O'LEARY,

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II.—ITS APPLICATION FOR CALORIFYING PURPOSES AND WORK DONE.

HAVING arrived at a determination as to the thermal value of the food ingested, the next point of inquiry to which we will direct our attention is its capability for supplying the heat necessary for calorifying purposes, and for accounting for the various opera accomplished by the system. In the determination of this, I have departed from the course pursued by such illustrious physiologists as Lavoisier, La Place, Dulong, etc. I have struck upon a new path more in accordance with the spirit of philosophy, and the sound principles of living physicists, as taught in the present day. Although this is one of the most important questions in the entire range of physiology, I have ventured to look with the eye of a physicist upon the inquiry; and have availed myself of the well-established laws of physics as aids in arriving at my conclusion.

A few years hence physiology will have been erected into a science, resting upon chemistry and physics, both bound together by, and exhibiting themselves, as vitality. I believe, therefore, it is all the more important to endeavour to arrive at a conclusion guided by these laws, rather than depend upon the results of former experiments, or the same ones repeated, no matter with what degree of extraordinary care, as, from the manner in which they were conducted, inevitable aberrations attend them; and their results are ever covered with a grave shadow of doubt: while, by appealing with confidence to the results of the ever-accumulating labours of the scientific physicist, we gain a sure foundation upon which to base our investigations. I will here state that I do not look upon the results I have obtained as perfectly accurate. I have had to rely upon data which the progress of science may alter and improve; but, as far as an earnest desire to arrive at accurate conclusions could assist, it has been brought to bear by me.

In endeavouring to ascertain the amount of heat required by the living body, I have pursued the following inquiries.

First. What amount of caloric would be necessary to give a similar amount of heat to any substance of the same weight and temperature of an animal? This, from a physical point of view, is easily determined; and I have followed the mode which a physicist would have adopted. I have selected water, therefore, as my standard. Having determined upon this point, my next step was to obtain the specific heat of the animal tissues as compared with that of water. My experiments for this purpose occupied several months of the present year, during which I laboured under serious disadvantages in consequence of the high temperature of the atmosphere. The instrument I first employed was Lavoisier's calorimeter, consisting of an inner chamber, containing the body, the specific heat of which was to be determined, surrounded perfectly with an ice-chamber; this I again surrounded by another chamber containing a further quantity of ice. The body in the inner chamber gives out its heat, and effects the liquefaction of a certain quantity of the immediately surrounding ice. By weighing the water so produced it is easy to calculate the heat given out by the body while cooling; as for every pound of ice liquefied to 32 deg. Fahr., heat is required equal to 79.4 deg. centigrade. Thus, having previously ascertained the weight and temperature of the body experimented on, we obtain its specific heat. The high temperature of the atmosphere seriously interfered with

this mode of experiment; as, when I endeavoured to verify it, I found I could not rely upon it for entire accuracy. I then adopted Black's calorimeter, which consists simply of a large mass of ice, within which the body for experiment is imprisoned. The principle upon which it yields results is precisely similar to Lavoisier's; and unfortunately I found it still liable to error from similar causes, but the results obtained by this method were tolerably constant. I further employed the method of mixture, which is an extremely simple one, but depending very much for accuracy upon surrounding influences. However, the result of my experiments leads me to fix the specific heat of the tissues of an animal at 0.48, as marked on chart.

The next point of inquiry is, the number of degrees which a body will lose in a given time. This depends very much upon two conditions—specific heat and conductivity. With the object in hand, I made numerous observations upon the dead human body; and my observations lead me to conclude that unless there be some special reason, such as peculiarity in the cause of death, etc., an amount of heat is given out equal to 5½ deg. Fahr. per hour. This result is much modified by circumstances other than the cause of death, such as the calibre of the limbs and the body covering of adipose tissue, etc. I have fixed the cooling number of my own body at 6 deg. Fahr., being rather of diminutive stature, and not overburdened with adipose tissue. The caloric necessary for this purpose I have calculated to be equal to 7464.96 thermal units. On referring to the accompanying chart, the mode of calculation will be easily understood.

The next subject of inquiry was the amount of heat lost to the system through the important agencies of the skin and lungs; this I divided into two parts: first, the consideration of what heat is expended by the conversion into a state of vapour of the water exhaled from the skin and lungs; second, the caloric expended in warming respired air. The result of the first I have based upon the six days' experiment. Having ascertained the amount of water exhaled from the skin and lungs, and its being necessarily converted into aqueous vapour, the calculation becomes a simple one. The laws of physics are very applicable here. For every pound of water converted into a state of vapour, an amount of heat is required sufficient to raise 537 lbs. of water 1 deg. centigrade, or 967 lbs. water 1 deg. Fahr. The expenditure of heat by this source equals 2369.1 thermal units. But, on referring to my former paper, it will be seen that an amount of hydrogen united with oxygen in the system capable of producing thirteen ounces of water, which at moment of combination was at combustion heat; but in the act of being reduced to the liquid state in the system, an amount of heat is produced equal to 785.6 thermal units. This gain subtracted from the loss, ascertained by the last calculation, viz., 2369.1, shows a net loss to the system of 1583.5 thermal units, as shown on chart.

With regard to the amount of heat expended in warming the respired air, I take 20 cubic inches as the amount of breathing or tidal air × 18 respirations per minute × 60 per hour × 24 per diem = 518,400 cubic inches = 300 cubic feet. One foot of air, by weight, equals 1.29 ounces; 300 feet equal 24.1 lbs. The temperature of the air entering and leaving the lungs was respectively 63 deg. and 99.5 deg. Fahr.; difference = 36.5 deg., which × 24.1 lbs. = 879.65 thermal units. This would be the amount of heat expended, provided the body heated was water. But the specific heat of atmospheric air compared to water = 0.236, which × 879.65 gives, as total loss of heat sustained in this act, = 208.4 thermal units Fahr.

There is an apparent loss of heat by the urine passing from the bladder at a high temperature; but, from observation on this point, I consider, if there be any, it is very trifling, as the food, and fluids, such as tea and the more invigorating tumbler of punch, ingested, nearly cover the difference between the cold fluid ingested and the urine and feces excreted. On reference to my former paper, it will be found that the food ingested daily, and oxidised in the blood, produced an amount of caloric equal to the raising of 6711.2 lbs. of water 1 deg. centigrade. Deducting from this the thermal value of the organic portion of the feces, which I have calculated, with as much accuracy as I could, as being equal to 100 thermal units, leaves 6611.2 thermal units centigrade. This, converted into the Fahrenheit scale which I adopted in my investigations, gives 11,900 thermal units Fahr. Subtracting from this 9256.86, the amount I have already shown as necessary for heating purposes, gives a surplus over thermal wants equal to 2643.14 thermal units, to be disposed of in the production of muscular force; the exact amount of which is easily ascertained thus: each thermal unit equals the raising of 772 lbs. one foot high × 2643.14 = 2,040,519.52 foot-pounds = 910.94 foot-tons, which is perfectly competent to cover all the opera required by the system.

From experiments in which I am at present engaged, I am induced to believe that the muscular force thus indicated has its source direct from the heat produced in the arteries, and not, as heretofore supposed, from

* Read before the Physiological Section at the Annual Meeting of the British Medical Association in Dublin, August 1867.