large obturator foramen is almost vertical in its long axis. The pubic diastasis measures (in the rearticulated specimen) 31 mm. The distance from the anterior margin of the acetabulum to the free margin of the os pubis is equal to the diameter of the acetabulum.

The upward displacement of the sacrum relative to the pelvis has been noted in other specimens by Ballantyne. It is a very remarkable anomaly difficult to associate with the primary malformation. In pelvis No. 2 it has led only to an abnormally high position of the sacrum, and to the assumption of some definitely lumbar characteristics by the first sacral element. In this case it has led to the almost complete liberation of this bone.

Although the general deformity consists in a splaying apart of the two ilia, it is noteworthy that the pubic diastasis is exaggerated in both specimens by an absolute shortening of the pubis. Whereas in this specimen the horizontal ramus of the pubis measures 63 mm., in a normal male bone of very similar general dimensions it measures 76 mm. Associated anomalies consist in (*a*) general flattening of the sacrum, (*b*) peculiar slenderness of the ischio-pubic ramus, (*c*) general uprightness of the whole of the ossa innominata.

CASE II (DR. NEWLAND'S).

Apart from an attack of measles in 1914, he remained in good health from the date of the operation in 1904 down to the time of his final illness in 1920. He worked on the family farm, and during his brother's absence on active service he managed it. In September, 1920, he weighed 10 st., the heaviest he had ever been.

In October, 1920, he consulted Dr. L. G. Muirhead, of Henley Beach, complaining of general weakness, abdominal pain, and some cough without haemoptysis. No pulmonary or laryngeal condition could be detected. He had complete control over his urine and could pass it irrespective of the act of defaecation. The urine on examination was turbid and contained a good deal of albumin. The kidneys were neither tender nor enlarged.

On his return to the country he consulted Dr. G. H. B. Black, of Showtown, and was admitted to hospital on November 23rd, 1920, complaining of weakness, wasting, and occasional slight pain below the left costal margin. He had suffered from indigestion for several months, and from a cough for several weeks. He stated that occasionally he had difficulty for a day or so in holding the urine in the rectum for any length of time, but as a rule there was no incontinence. He was very wasted; the heart and vessels were natural. Slight pleural friction could be detected at the posterior base of the left lung. The kidneys were neither palpable nor tender. The healed scar of the old operation, in the pubic region, was partly covered with pubic hair. The penis was rudimentary. There was little hair on the face and the voice was falsetto. A filtered specimen of urine was free from sugar.

On December 2nd doubtful signs were detected at the apex of the right lung. On December 10th there were signs of a cavity in the same situation and tubercle bacilli were found in the sputum. A week later signs of consolidation developed in the lower lobe of the left lung. His general condition now rapidly deteriorated, and after an attack of "convulsions" he died on January 15th, 1921. An autopsy was not performed, and therefore no report on the condition of the kidneys is possible.

REMARKS.

The principal object of this paper is to encourage surgeons who may encounter these rare cases in future to operate upon the lines laid down in the communication referred to above,[1] for, if a child of 9, whose left ureter was noticed to be much thickened at the time of operation, can survive in comfort for about twenty years, and follow his occupation for eighteen years till disabled by cardiac dropsy, how much better results may reasonably be expected when clean cases are operated upon before the ascending ureteritis has set in. It would be interesting to learn the ultimate result of the cases reported in your columns by C. J. Bond,[6] Gilbert Barling,[7] Murray,[8] Riddell,[9] Lawford Knaggs,[10] Rigby,[11] Ball,[12] Arumugum,[13] Holman.[14] Mr. Bond's case[6] survived six years, according to a letter from him dated October, 1906, but this may be an error, as in his original report he gave the date of operation as 1903. Dr. Hatch, of Norwich, and formerly of Bombay, wrote of a successful case reported to the East Anglian Branch in 1904. The only cases we can find in recent Australian literature where this method was adopted are reported by Dr. Hamilton Russell, of Melbourne[15]: his three cases gave excellent results. Dr. Stewart McKay, of Sydney,[16] planned an ingenious operation on the old lines of closing in the bladder: he introduced a tube of rectal mucous membrane into the bladder to avoid the ureteral orifices coming into contact with faeces.

REFERENCES.

[1] BRITISH MEDICAL JOURNAL, April 28th, 1906. [2] Jaromir Jelinek *Exstrophia Vesicae Urinariae*, 1908. [3] *Canadian Lancet*, 1899, xxxii, 23; BRITISH MEDICAL JOURNAL, June 22nd, 1901. [4] *Surgery, Gynecology and Obstetrics*, February 1909, p. 146. [5] *Transactions*, Intercolonial Medical Congress of Australasia, 1902. [6] BRITISH MEDICAL JOURNAL, May 19th, 1906. [7] Ib., January 19th, 1907. [8] Ib., November 2nd, 1907. [9] Ib., April 25th, 1908. [10] Ib., October 24th, 1908. [11] Ib., December 12th, 1908. [12] Ib., January 30th, 1909. [13] Ib., April 1st, 1911. [14] Ib., January 31st, 1920. [15] *Med. Journ. of Australia*, January 5th, 1918. [16] *Australasian Med. Gazette*, August 21st, 1911.

ON THE ESTIMATION OF THE PHYSIOLOGICAL COST OF MUSCULAR WORK:

THE SIGNIFICANCE OF THE RESPIRATORY QUOTIENT IN INDIRECT CALORIMETRY.

BY

J. B. ORR, D.S.O., M.A., D.Sc., M.D.,

ROWETT RESEARCH INSTITUTE, ABERDEEN;

AND

J. P. KINLOCH, M.D., D.P.H.,

PUBLIC HEALTH DEPARTMENT, UNIVERSITY, ABERDEEN.

IN an article in this JOURNAL (May 21st, 1921, p. 733) Leonard Hill and Campbell show that in the estimation of the physiological cost of muscular work there is a lack of agreement between the results obtained by the method practised by Waller and De Decker[1] and that recommended by Cathcart. Waller and De Decker base their estimation on the exhalation of CO_2, 1 c.cm. of CO_2 being taken as equivalent to 5.856 calories. In the method described by Cathcart[2] the estimation is based on the absorption of oxygen, the caloric value of 1 c.cm. of oxygen varying with the respiratory quotient—that is, the ratio of the volume of CO_2 exhaled to the volume of oxygen absorbed during the same time. Leonard Hill and Campbell consider that two sources of error in the results of Waller and De Decker are (1) the short duration of the period of taking the sample, and (2) the failure to take sufficient account of the increase of metabolism due to taking food.

The source of error, however, which is inherent in Waller's method is the neglect of the significance of the respiratory quotient (R.Q.) in determining the caloric equivalent of the volume of CO_2 exhaled. According to Waller,[3] one cubic centimetre of CO_2 is equivalent to 5.317 calories when the R.Q. is 0.95, and to 6.396 when the R.Q. is 0.75. In assuming a fixed R.Q. of 0.85, and a consequent constant value of 5.856 calories per cubic centimetre of CO_2, there is ample room for a wide error, even though the other source of error pointed out by Leonard Hill and Campbell were eliminated. On an uncontrolled diet the R.Q. is sometimes as high as 0.95 or as low as 0.75. On special diets it may fall outside these limits. Table I shows the extent of the error that may occur. The subject and the work—marching at 100 yards per minute on a level floor—were the same in both cases. The diet was uncontrolled.

TABLE I.—*Showing Extent of Error.*

Subject accustomed to apparatus (5 minute samples).

Date.	CO_2 exhaled per minute.	Oxygen absorbed per minute.	R.Q.	Calories calculated from Oxygen Consumption Factor varying with R.Q.	Calories calculated from CO_2 output, R.Q. assumed 0.85.
1919. Jan. 8	c.cm. 743	c.cm. 989	0.75	4.69	4.35
Jan. 9	865	960	0.90	4.73	5.07

The energy expenditure in the two cases as calculated from the exhalation of CO_2, assuming a constant R.Q. of 0.85, shows a difference of about 15 per cent., although the real expenditure as calculated by the more exact method differs by less than 1 per cent. The usefulness of this rapid method of estimating the physiological cost of muscular work by simply measuring the CO_2 output is

thus limited to the approximate determination of the relative severity of the work. Waller is, of course, aware of the source of error in the method, though he has probably underestimated the range of error.

Even in the exact method recommended by Cathcart, in which the caloric value of the oxygen varies with the R.Q., care has to be taken to ensure that the R.Q. represents tissue respiratory exchange. Analysis of expired air frequently shows a quotient that is quite fictitious. This erroneous result arises in the following way. In the body there is a large store of loosely held CO_2 which can be washed out by excessive respiratory efforts, or displaced by acid products of metabolism. On the other hand, part of the CO_2 produced in the tissues may temporarily accumulate within the body. In any sudden change, therefore, in the rate or amplitude of respiration or in the rate of metabolism, as in passing from rest to work or vice versa, there is apt to occur a washing out or retention of CO_2 which completely upsets the relationship between the CO_2 output and the rate of metabolism. The oxygen exchange is, on the other hand, much more steady. Hence, when a washing out of CO_2 occurs, there is not a balancing "washing in" of oxygen, and the R.Q. consequently rises. In the same way, on a temporary retention of CO_2 the R.Q. falls. In sudden changes of the rate of respiration, therefore, there may occur wide fluctuations in the R.Q. which are not a true reflection of tissue metabolism.

In connexion with some experiments which were being carried out we found it necessary to determine the nature of the fluctuations of the R.Q. liable to occur in sudden increases or decreases of the rate of work. Our results obtained for half-hour periods of work of moderate severity show that on passing from rest to work the R.Q. immediately drops and then rises, usually above the pre-work level, after which it slowly falls to the pre-work level. On passing from work to rest there is a sharp rise in the R.Q. followed by a fall below the pre-work level. Table II shows the nature of the fluctuations; the work consisted in marching at a uniform rate of 120 yards per minute.

TABLE II.—*Nature of Fluctuations of R.Q.*

Subject accustomed to apparatus.

R.Q.		Calories per Minute.	
94	.....	1.28	Rest.
74	.....	5.33	First minute work.
89	.....	8.44	Third minute work.
97	.....	8.19	Fifth minute work.
91	.....	7.55	Seventh minute work.
94	.....	7.55	Twenty-fifth to twenty-seventh minute work.
101	.....	4.93	First minute rest after work.
98	.....	1.71	Third minute rest after work.
105	.....	2.01	Fifth minute rest after work.
90	.....	1.55	Seventh minute rest after work.
80	.....	1.23	Twentieth to thirtieth minute rest after work.

A rise in the R.Q. shortly after the commencement of work and a sharp rise on the cessation of work have been noted by several workers. The extent and the causes of these have recently been studied by Campbell, Douglas, and Hobson.[4] Apart from these more or less regular fluctuations there occur occasional changes in the R.Q., such as the sudden rise in the fifth minute after work in the above table. These we believe are connected with changes in the rate of respiration. All these changes in the R.Q. are undoubtedly due to the gap that exists between tissue respiration and tracheal respiration. They merely indicate a washing out or retention of CO_2 in this undetermined zone.

From the foregoing considerations it is obvious that any sudden alteration in the R.Q. suggests that the result is vitiated by a wash out or retention of CO_2. In determining the energy expenditure, therefore, it is necessary that the rate of muscular work should have been constant for about ten minutes before the sample of expired air is taken. If the work is very severe a longer period may be necessary. The constancy of the R.Q. at or about the level of the preceding period is the indication that equilibrium between tissue respiration and tracheal respiration has been established, and that the result may be relied on to represent tissue metabolism. It is obvious that in the method of estimating the cost of work from the CO_2 exhalation, results obtained at the beginning of work or immediately after the work stops are of little value. In the former case CO_2 is accumulating within the body, while in the latter it is being washed out. In neither case is there any parallelism between the production of CO_2 in the tissues and the exhalation of CO_2.

The consideration of the R.Q. is of interest apart from the accuracy of the determinations. Krogh and Lindhard[5] have shown that the physiological cost per unit of work is less in the post-absorptive state following a high carbohydrate diet than following a high fat diet, and Orr and Kinloch[6] have shown that following a meal the net cost of the work—that is, the rate of metabolism during work *minus* the rate of metabolism during the preceding rest period—is greatest on a high protein diet and least on a high carbohydrate diet. The net apparent cost of the work therefore depends to some extent on the nature of the material being consumed in the muscles which is indicated by the respiratory quotient.

Note.—The first observations on which the above note is based were made when one of us (J. B. O.) was working with Professor Cathcart, F.R.S., at the London Hospital in the winter of 1918-19. The results of Table I are taken from unpublished results of that period and included here by the kind permission of Professor Cathcart.

REFERENCES.

[1] BRITISH MEDICAL JOURNAL, May 7th, 1921, p. 669. [2] *R.A.M.C. Journal*, November, 1918. [3] *Proceedings of the Physiological Society*, March, 1919. [4] *Transactions of the Royal Society*, 1920, vol. B, 210, p. 1. [5] *Biochemical Journal*, 1920, vol. 14, p. 290. [6] *R.A.M.C. Journal*, February, 1921.

THE CONTROL OF HAEMORRHAGE BY INTRAMUSCULAR INJECTION OF CALCIUM CHLORIDE.

BY

W. R. GROVE, M.D., ST. IVES, AND H. W. C. VINES, M.B., BEIT MEMORIAL RESEARCH FELLOW.

THE treatment of haemorrhage by intramuscular injection of calcium chloride is gradually becoming a well recognized and useful procedure, but we know of no published results which show what has taken place in the blood, or how long the drug may be acting. Originally it was pointed out in the *Guy's Hospital Gazette* of May 18th, 1918 (W. R. G.), that the credit for the use of the drug is due to Dr. W. E. Dixon. One of us (H. W. C. V.) has now examined the blood after many of these injections, and, though his results will be published later, it seems worth while to publish separately a short statement from the practical point of view.

One grain of calcium chloride is dissolved in about 100 minims of water and injected deeply into the gluteal muscles; it must not be injected subcutaneously or sloughing of the skin will be caused. If a solution of the salt is made up to a concentration of 1 in 4 (2 drachms in an ounce is a convenient quantity), four minims then contain one grain. This solution has been kept for weeks, and in this strength apparently remains sterile indefinitely. If the solution is not quite clear, it must be shaken before use. The four minims are diluted to 100 mm. with boiled water, and in some hundred or more injections nothing abnormal has developed at the site of injection. Generally the injection is painless, though a few patients have complained of pain and stiffness running down the limb. In the blood the calcium value is found to rise slowly to a maximum in six hours, and then to remain practically constant for at least twenty-four hours. It is not at present possible to state definitely the action of calcium salts in controlling bleeding; it is probable that there is a direct constrictor effect on the blood vessels, and, further, the increased calcium content of the plasma may cause combination to occur between the calcium and the blood lipoids, with a consequent acceleration of clotting.

As a practical application of these results it has been found perfectly safe to give a second injection at the end of twenty-four hours, and, if necessary, a third twenty-four hours later; this was actually done in a case of haematemesis. In anticipating haemorrhage at or after operation, an injection not more than two hours before, or even at the time of operation, would seem indicated.

Calcium salts given by the mouth had no influence on the blood calcium; this confirms the observations of Dr. Dixon, from whom this treatment originated. It may