

On steatosis : or adipification of muscle / by C. H. Hallett.

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"The Author's Compliments"

ON

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STEATOSIS;

OR

ADIPIFICATION OF MUSCLE.

BY C. H. HALLETT,

LATE DEMONSTRATOR OF ANATOMY IN THE UNIVERSITY OF EDINBURGH.

(From the Edinburgh Medical and Surgical Journal, No. 179.)

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ON STEATOSIS;

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IN a former number of this Journal (No. 174), when describing the anomalies of the muscular system which had been observed in the bodies dissected in the practical rooms of the University of Edinburgh during the years 1846-1847, I had occasion, in the general remarks, to allude casually to a very remarkable instance of steatosis, or adipification of muscle, which had fallen under my notice at the commencement of the winter session of the latter year. Since that time, I have observed and carefully examined other instances of this pathological condition of the muscles, both in the human subject and in one of the lower animals. I therefore take this opportunity of redeeming the promise I then made the readers of this Journal to describe the case, and, at the same time, to notice the nature and general characters of the transformation, at least as far as my own observations and those of some of the continental pathologists will admit.

William Speed, aged 78, died of paralysis on the 8th day of December 1846. A few days after death, the body was transmitted to the University for dissection, the encephalon having been removed at a *post-mortem* examination. He appeared to

have been, during his life-time, a strong robust man ; the chest was large and capacious, the limbs bulky and firm, and, as far as it was possible to judge from external appearances, the whole muscular system seemed more than usually well developed. The removal of the superficial textures, however, immediately dispelled the previously-formed opinion of the fitness of the subject for dissection, since all the muscles of the back, the part first dissected, could not be distinguished by their colour ; the fibrous character of some structures composed almost entirely of fat, and the direction or course of the fibres alone indicated the position of, and the lines of demarcation between, the various muscles in the whole of the dorsal region. On turning the body, the muscles on the upper part of the trunk were found in precisely the same condition. All the muscles in the body were subsequently examined in detail, and but few were found that had entirely escaped the fatty deterioration.

Some of the muscles had been apparently entirely transformed into adipose tissue. Others had been only partially transformed, many of these having three-fourths or more of their muscular appearance destroyed ; the remaining portion, although wearing a fleshy aspect, presented very evident indications of the process of adipification being in full force up to the time of death. A few retained more of their normal appearance, in consequence either of a small portion only having been converted into fat, or of the adipose matter having distributed itself equally and comparatively in small quantity throughout the whole muscle, giving it a peculiar mottled aspect. I shall, therefore, in noticing the case in detail, first enumerate those muscles which had been wholly converted into fat, and then enumerate those which had undergone only a partial adipification, in each region of the body.

1st, In the back, the face, and region of the scalp, all the muscles, with the single exception of the *latissimus dorsi*, which was only partially changed, were apparently completely converted into adipose substance.

2dly, In the anterior cervical region, the only muscles which were observed to have undergone any appreciable transformation were, the *recti antici majores* and *minores* ; the *longi colli*, and the *scaleni antici* and *postici* ; and these had been completely transformed.

3dly, In the region of the trunk, the muscles which had been wholly converted into fat were the pectoral muscles, both greater and lesser, on each side ; the *serrati magni*, the *triangulares sterni* ; the diaphragm, both external obliques ; and, on the right side only, the *psoas magnus* and *quadratus lumborum*. Those partially transformed were the intercostals, both external and internal, the fatty matter being distributed in small patches through-

out their whole length; the *recti abdominis*, the whole lower four-fifths of which were wholly transformed, while the upper and remaining fifth presented some small patches radiating upwards; the internal obliques, all below the level of the anterior superior spinous process of the ilia in both being unchanged; the *transversi abdominis*, the superior third of that on the right side, and the lower half of that on the left side of the abdomen, being, for the most part, unaltered; and, lastly, the pyramidales and cremasters, which were dotted over with fat, and presented the peculiar mottled appearance of muscles infested with the *Trichina spiralis*.

It may be necessary to remark in this place, in connection with this extensive deterioration of the muscles of inspiration, that it was in this subject the highly-developed, robust, and fleshy *rectus sternalis* or *sternalis brutorum* muscle, which I have described in the number of this Journal referred to, at the commencement of this memoir, existed, and was, in this instance, the principal, perhaps the only, agent by which the chest was expanded in the act of inspiration.

4th, In the upper extremities, the muscles apparently wholly transformed were the *triceps extensor*, the *biceps flexor*, and the *brachialis anticus* in both arms; the biceps, on being cut transversely, presenting some remains of its fleshy hue in the centre of the section; the *supinator longus*, the *extensor carpi radialis longior* and *brevior*, and the *anconeus* in both fore-arms; the *extensor communis digitorum* and the *extensor indicis* in the right fore-arm only; and in the hand, the whole of the palmar muscles of the thumb and little finger. Those partially transformed were the deltoid, and all the muscles about the scapula inserted into the upper part of the humerus, in both shoulders; the *flexor carpi radialis* and *palmaris longus* in both fore-arms; the *flexor carpi ulnaris* and *flexor profundus digitorum* in the right fore-arm, and the *extensor ossis metacarpi pollicis* in the left fore-arm. In all the last named muscles, the exterior had been wholly converted into fat; but on being divided, more or less of the centre was distinctly fleshy, and the characters of muscular fibre were easily detected. The *flexor carpi radialis* formed the only exception to this rule, the upper part of this muscle only being changed, and that in such a manner as to present the appearance of a conical cylinder of fat being applied on a pyramid of muscle.

5th, In the inferior extremities, the muscles wholly transformed were observed to be, in each hip, the *glutæus maximus* and *medius*, the *quadratus femoris*, and the two *gemelli*; the *biceps flexor cruris*, the *semitendinosus* and the *semimembranosus* in the posterior region; the *quadriceps extensor* and *triceps adductor cruris*,—with the exception of the *adductor longus*, which was

normal in every respect,—in the anterior region of both thighs. Those partially transformed were found to be the *iliacus internus*, the *obturator externus* and *internus* on both sides of the pelvis, all of them being mottled over with fat; the *glutæus minimus*, which, on the right side, presented its lower half changed, and on the left side had its anterior two-thirds curiously streaked with fat; the *pectineus*, studded with adipose substance over its whole extent; and all the muscles of the posterior region of the leg, including the *poplitæus* and all those of the sole of the foot, without exception, these muscles presenting the same peculiar appearance as the *pyramidales* and *cremasters* in the trunk.

None of the involuntary muscles were changed in an appreciable degree. The heart, which is usually classed amongst these, but presents the same ultimate structure in the *fibrillæ* as the voluntary muscles, formed an exception to this rule; its surface being not only more loaded with fat than ordinary, but its substance being also infiltrated with adipose matters to near the inner surface of its several cavities, where the fleshy appearance was still retained.

Before entering on the more minute details of this case, or attempting to describe the general nature and course of the process of adipification of muscle, it is necessary that I should place before the reader those cases which have been recorded by others, and which, from their extent, and the peculiarities presented by them, have enabled me, in conjunction with those observed by myself, to deduce some general laws which appear to regulate the change.

The case which appears to approach most closely to that just described, at least in extent, is one observed and recorded by Dumas. On examining the body of a man who had died under fever accompanying catarrh, he found all the muscles on the anterior aspect of the chest, together with those on the posterior part of the region of the shoulder and of the arm, changed into fatty matter, and surrounded with a sheath of condensed areolar tissue, which affected the form and figure of the muscles whose place it occupied. Some others of the muscles, as those of the abdominal walls, and the *triceps extensor cruris*, announced, by an alteration in their colour and consistence, that, although the transformation was by no means complete, the process of adipification was going on in them. The *glutæus maximus* and first adductor of the thigh were also partially converted into fat, but they still presented some muscular fibres scattered through the mass of adipose matter.

Vicq d'Azyr, after mentioning that he had seen two slight cases of fatty transformation of muscle, describes, with his accustomed care and minuteness, an instance of extensive change in the muscles of the inferior extremity of an old subject which he had dissected. With the exception of the *glutæus maximus*, which re-

tained its natural fleshy appearance, all the muscles in the left lower extremity were observed to be pale and more or less completely converted into fat. The superior portion of the *semitendinosus* and of the *biceps flexor cruris*, the *gastrocnemius*, the extensors of the toes, including that of the great toe, and the *tibialis anticus*, were the only muscles in which marked traces of fibres could be found. All the rotator muscles of the thigh, those placed in front of the femur, the *iliacus internus* and the adductor muscles, as well as those of the sole of the foot and the posterior region of the leg, were apparently wholly converted into fat, so much so, that it was difficult to discover any vestiges of their fibres in the position they normally occupy. On examining the *sartorius*, between its two points of attachment, the successive degrees of the process of transformation were observed, the gradual transition from muscle to fat being clearly discernible; the lower part of this muscle was so completely transformed as to be scarcely distinguishable from the fat about the knee. The man on whose body this observation was made, had been a cripple some years before his death.*

Maugre, on amputating the thigh of a young man for an ununited fracture of three years and a half's standing, discovered all the muscles of the leg, as he relates, totally converted into fat, the only exception being the *gastrocnemius*, which still retained some fleshy substance nearly the size of the thumb. He also states, that, on dividing the muscle, he could clearly trace some red fibres in their interior.†

In his great work on pathological anatomy, Cruveilhier relates a case of fatty transformation of the muscles of the leg, in connection with club-foot, of many years' standing. He discovered the *tibialis anticus*, the long common extensor of the toes, the proper extensor of the great toe, the short extensor of the toes, the long flexor and the accessory flexor of the toes, together with the proper flexor of the great toe, completely transformed into fat. The *gastrocnemius* and *solæus* were observed to have been only partially transformed, the internal head of the former and the outer half of the latter still preserving much of their fleshy appearance.‡ Cruveilhier also mentions that he had seen other cases of the same kind.

* Œuvres de Vicq d'Azyr; par Jacq. L. Moreau, T. 5, p. 365. Sur une extrémité inférieure dont les muscles ont été changés en tissu graisseux, sans aucune altération dans la forme extérieure.

† Journal Général de Médecine, T. 24, p. 6. Rapport sur une observation relativement à une dégénération de la presque totalité des viscères de l'abdomen; et observations sur la transformation des différentes parties du corps humain, par F. T. Double.

‡ Anatomie Pathologique du corps humain, Vol. i. livr. 11, p. 3, pl. 111. Examen anatomique des muscles, des ligaments, &c.; dans le pied-bot.

Louis also, on dissecting the amputated lower extremity of a subject, observed that the *gastrocnemius*, the *solæus*, the *plantaris*, the *popliteus*, the long common flexor of the toes, the proper flexor of the great toe, and the *tibialis posticus*, were converted into adipose substance.*

Lastly, in a woman who had died shortly after bearing a child, Emmanuel, who was obliged to make the examination by stealth, observed the muscles forming the abdominal parietes completely converted into fat.

Besides the cases brought together in this memoir, others, more or less extensive, have been seen and mentioned by Salzmänn, Leuwenhoeck, Albinus, Haller, and many other anatomists ; but I am not aware that they have given any detailed account of their observations.† I may here state, that the other instances of this pathological condition of the muscles in the adult human body which have fallen under my notice, were, first, almost complete transformation of the muscles in the anterior and external region of the leg in connection with club-foot, the fleshy hue being only discernible in the interior of the muscles ; secondly, partial transformation of all the muscles of the leg, consequent on ankylosis of the knee-joint and disease of the tarsal bones ; and lastly, complete transformation of the deltoid muscle, probably resulting from injury of the circumflex nerve from dislocation of the head of the humerus into the axilla. In none of these cases, however, was there any other peculiarity noticed worthy of especial mention.

From the observations hitherto recorded, it would appear that the fatty transformation of muscle is strictly confined to that kind of muscular fibre called striated, comprising all the muscles of animal life, and the heart, which is also ranked from its mode of action, amongst the involuntary muscles, or muscles of organic life. Kerkring, Bonet, Morgagni, Cruveilhier, Laennec, and Adams‡, have all seen and described examples of fatty transformation of the muscular substance of the heart. In all these cases, as well as my own, the fatty matters had been deposited, for the most part, in the fibres towards the surface of the several cavities, the inner fibres and the *columnæ carneæ* being free from fat, and possessing their normal appearance ; and it may be stated in connection with this, that, whenever the heart is found to have un-

* Journal Generale de Medecine, t. 24, p. 5.

† Vide Œuvres de Vicq d'Azyr, loc. cit., and Journal General de Medecine, loc. cit. Salzmänn is described as having seen muscular fibres converted into a fatty mass. Leuwenhoeck is cited by Haller as having seen not only the muscles but the tendons also adipified. Albinus, after describing the muscles in general in his work, "De musculorum Hominis," says, "Pinguine ita distenditur aliquando ut reliqua musculorum sufficit : tendines vero pinguidina tam facile non cedunt ;" implying that he had observed the change.

‡ Vide Essai d'Anatomie Pathologique, Vol. 1, p. 183 : and Craigie's Pathological and General Anatomy, art. Steatosis.

dergone the fatty transformation, it will be found to conform in every respect to the general rules regulating the process in the so-called voluntary muscles, with which it corresponds in structure, and that it offers the best place to follow the various stages of the change, as hereafter described.

The lower animals are not altogether exempt from this morbid state of the muscles, for fatty muscles have been detected in more than one instance in the sheep. Vaughan records an extensive change in the muscles of a sheep which he dissected,* and I have lately had an opportunity of examining it in the muscles of the back of a sheep, which was stated to have had all the muscles in its body transformed into fat;—a portion of this last instance is amongst the stock preparations of the museum of the Royal College of Surgeons of England. From the observations I have made on this specimen, I am enabled to state that the process of transformation appears to follow precisely the same course as in man.

Haller has recorded his opinion that the muscles in monsters are not unfrequently found more or less fatty.† That the muscles are often replaced by compact fat, bound down by and intermixed with much condensed areolar tissue, in monsters presenting great defect and deformity, is well known to those anatomists who have devoted much time to teratological studies, but whether such a change occurs in monsters by excess or redundance may well be questioned. Although I have dissected numerous monsters by excess, I have never been able to detect the slightest trace of fatty transformation of the muscles; and although I have noticed fat replacing the muscles in monstrosities by defect, I have never been able to satisfy myself that muscular fibre had ever existed where the fat was found.

Adipification of muscle is the result of various diseases, which prevent the due exercise, and consequently interfere with or pervert the nutrition of one or more of the muscles in any or several of the regions of the body. Amongst the most extensive and most powerful in effect of such diseases, confirmed paralysis, proceeding from disease of the nervous centres, ranks first, and rachitis, when the deformity consequent on it is extensive, and the interference with motion is great, ranks next in order. Club-foot,

* Some Account of an Uncommon Appearance, &c. London, 1813. A highly speculative essay on alteration of the muscles in the Strood sheep. I may quote here the following words, as bearing more directly on the subject under consideration:—"On minute examination, no vestige of fibre could be discerned, but only minute particles, the figure of which it was impossible to ascertain." Some of the muscles in the cervical region were not wholly converted into fat.

† *In morbis rarum, in monstribus vulgare vitium est.* Vicq d'Azyr also dissents from this conclusion of Haller, on the ground that fatty muscle is but rarely seen in any case; but this, perhaps, is also as far from the truth.

ankylosis, and unreduced dislocation, when of long standing, are not unfrequent causes of it. Paralysis from direct injury to the trunk of a nerve has caused it. According to Cruveilhier, it not unfrequently is the result of old ulcers, when of great extent, of long standing, and where they materially interfere with the motion of the diseased limb. It has also been stated that the muscles of the calf of the leg and *erector spinæ* muscles undergo fatty transformation in old people, from disease of the limbs or other causes. My own observations, however, on such cases of alleged transformation, show that it is in general, if not always, an entirely different change from that under consideration.*

Whatever disease may be the cause of the transformation, it may be laid down as a general rule that, in all cases, the process of adipification of muscle is extremely slow in its progress, and that it requires considerable length of time for its full completion. From numerous careful examinations of muscles, in which the deposition of adipose matters was found in its slightest degree with the microscope, I have been enabled to determine that the fat is first traceable within the sarcolemma, where it is found in minute globules closely packed together, and arranged for the most part in linear series. In this stage of the process there may be also occasionally seen a few perfect fat corpuscles, enclosed within the sarcolemma, filling up its entire breadth, and sometimes causing it to bulge outwards on either side. The fat globules and corpuscles are highly refractive, and appear as dark spots of various sizes; they can be easily discerned with an achromatic lens magnifying 250 diameters. Whether the fat globules are contained within the myoline, or whether they merely displace it, cannot be satisfactorily determined, at least I have not been able to satisfy myself on this important point. One thing, however, appears certain—namely, that there is in this stage of the process no appreciable diminution in the amount of myoline; for, on treating a small portion of the muscular fibre presenting the above appearances with sulphuric æther in an animalcule cage or compressorium (to prevent rapid evaporation), the fat globules and corpuscles are soon dissolved out, and the ultimate fibril is found to retain its normal appearance in as far as the eye can distinguish.

If a portion of muscle, in which fat has been deposited to the extent of about an inch be examined with the microscope, the adipose corpuscles and globules, the former more especially, will be found to have greatly increased in number within the sarco-

* It is to be remarked, that steatosis or adipification of muscle results from an entirely opposite condition of the system which appertains to fevers and other wasting disease, and therefore any hypothesis which may be advanced to explain the nature of the change must be based on this difference. In this memoir I have purposely abstained from all hypotheses, and confined myself strictly to facts.

lemma, in those parts of the fibrillæ which have undergone most complete transformation, while but few can be detected near those parts in which the process of transformation has only just commenced. Again, if the portion of fatty muscle under examination be macerated in ether, or submitted to the action of boiling alcohol for some time, and then re-examined, the fat corpuscles and globules will be found to have almost entirely disappeared, and but few of the corpuscles characteristic of muscle will be observed where the fatty matters were most abundant; they have for the most part disappeared, or, more likely, have entirely changed their character. In this stage of the process of adipification, fat globules and corpuscles can be detected sparingly distributed in the meshes of the areolar tissue connecting the fibrillæ and fibres together.

The gradual deposition of adipose substances can be traced proceeding onwards, in this way, from one end of a fibre or fibrilla to the other, or from its centre towards either extremity, the fat corpuscles becoming relatively more numerous as the transformation goes on, both within the sarcolemma and in the meshes of the areolar tissue connecting adjoining fibrillæ together. When the deposition of fat has advanced to its greatest extent,—in other words, where the muscle is apparently wholly converted into fat, there being no marked traces of muscular fibre visible to the naked eye,—myoline, although in extremely small quantity, is still capable of being detected by the microscope. It is not uncommon to find the sarcolemma ruptured, and one or more fat corpuscles protruding from it; that this is not always the result of the manipulation with the needles necessary to prepare the fibre for minute examination, is shown by the fact that it seldom occurs or is met with in fibres which have not been wholly transformed; and also by its sometimes being impossible to trace the sarcolemma for any great distance, in consequence of its being completely broken up and destroyed; so that we must ascribe the rupture to a diminution of the elasticity and power of coherence of the sarcolemma consequent on the deposition of fat both within and around it,—an effect which is well known to follow the accumulation of fat beyond its normal quantity in any texture. The only other change worthy of mention where the muscle appears wholly transformed, was observed to be a greater relative amount of fat globules around the fasciculi of fibres; but this would appear to be the result of the breaking up of the sarcolemma in adjoining fasciculi at least to a great extent.

It is this stage of the process of adipification of muscle which Vicq d'Azyr undoubtedly intended to describe in his comments on the case, of which an abstract has been given in this memoir.*

* Loc. cit.

Considering the time at which he wrote, and the imperfect instruments for minute observation at his command, his description is of sufficient interest to be transcribed here, more especially as it shows that he was fully aware of the first site of the change. He observes, "on pressing a portion of altered muscle strongly, a large quantity of fat, differing in no respect from that found in other parts of the body, is expressed. On examining such a portion of muscle with a lens of high magnifying power, it presents an assemblage of soft transparent fibres, the diameters of which differ in different parts of their length, and which in certain fibres appear to be divided into a great number of small compartments. When the fibres are carefully separated from one another, their organization is in part destroyed, and the lens exposes to view the whitened laminæ which connected them, and in each interstice a little fatty matter which pressure has caused to escape." And again he states emphatically, it is not between the fibres that the fatty matters are deposited, but within the elements of the fibres themselves.*

This statement of Vicq d'Azyr is adopted by Cruveilhier,† who proceeds to observe that the muscles at first present their natural aspect, only they are somewhat paler than ordinary,—the linear disposition of their fibres being always evident. A muscle in such a state may not be pronounced at first sight to be fatty, but on making a section of the muscle, and pressing it against linen or bibulous paper, an evident oily stain is made. Such a mode of examining a muscle supposed to have undergone adipification, however, is sometimes fallacious, and can never be relied on.

The question as to what part of the ultimate structure of the fibrillæ is the first seat of the change, is one which cannot, in the present state of our knowledge of the minute anatomy of muscle, be answered in anything like a satisfactory manner. We first detect the fatty matter within the sarcolemma; but whether it is deposited within the cells of the myoline and these become fat cells, or whether it is deposited in the spaces between the cells and these are removed as the quantity of fat is augmented, cannot be fully determined. Analogy would lead us to presume the former; for other organs, in undergoing the process of fatty transformation, have the adipose matters first deposited within the cells, which form the most essential part of their structure. In the liver the fat is first detected within the biliary cells, and spreads from them to the surrounding interstitial substance; and, in true fatty degeneration of the kidney, the fat is first deposited in the secreting cells in the uriniferous tubes. This, taken in connection

* Op. cit. Ce n'est point entre les lames que le tissu graisseux paroît être épanché, mais bien entre les élémens de la fibre elle-même.

† Essai l'anatomie pathologique. Paris, 1816. Vol. 1, p. 185.

with the facts, that fat globules are distinctly traceable within the sarcolemma without any appreciable diminution in the myoline, in the first stage of the process of adipification, and that myoline afterwards disappears in direct proportion to the increase of fat within the sarcolemma, would tend to sustain the hypothesis, that the ultimate cellular structure of muscle is the primary seat of the change. Could this be demonstrated satisfactorily, we should be able to propound a law of general application to true fatty transformations.

The microscope shows that the transformation of muscle into fat takes place slowly; and this is also clearly demonstrable to the naked eye. We are also almost invariably able to demonstrate another fact, which, from the numerous statements and descriptions of those who have recorded cases, deserves to rank as a general law. I allude here to the very remarkable, but altogether inexplicable circumstance, that the circumference or surfaces of a muscle undergoing fatty transformation are always first converted into fat; in other words, that the adipose matters are first deposited in the outermost fibres, and subsequently in those towards the centre. In consequence of this, a muscle which at first sight appears to have been wholly converted into fat, on being divided, exhibits, where the transformation has not proceeded to its greatest length, more or less of unchanged muscular fibre in the centre. This is best seen in the long muscles of the extremities; but the flat muscles, as those of the anterior abdominal walls, the muscles of the chest, the trapezius and serrati, also follow the same law; for when not wholly adipified, the fat is observed to extend over and involve a greater extent of the external than of the internal fibres, although in by no means so marked a degree as in the muscles of the extremities.

Another circumstance connected with the adipification of muscle seems also worthy of special mention, namely, that the deposition of adipose matter, and the absorption or removal of the true muscular substance, appear to proceed "*pari passu*;" so that, on a muscle being apparently converted wholly into fat, there is no evident or appreciable diminution in the bulk, nor any alteration in form or figure of that muscle. On comparing muscles which are adipified with others in the same or opposite extremity, or side of the body, which are wholly free from fat, the eye can detect no difference, except in regard to colour. All the cases noticed by myself exhibited this in a most marked manner; and others, as Vicq d'Azyr and Cruveilhier, make distinct mention of it in their description of cases. Atrophy of a muscle, therefore, would not appear to be a result of adipification, as some pathologists have supposed; for the smaller size and atrophied appearance of the transformed muscles in cases resulting from club-foot, an-

kylosis, old ulcers, and other causes arising from local changes or diseases, are explicable, on the ground that either congenital deformity has interfered with the growth, or acquired deformity or disease prevented the proper nutrition of the muscles, before they had undergone adipification. Besides, it is to be remembered that the muscles are not always diminished in size in cases of muscular adipification accompanying or resulting from acquired deformity ; and, consequently, the conclusion that, where muscles are atrophied, the wasting away of the muscular substance has preceded and is independent of the deposition of fat, is perfectly correct.

There now remains but one other point in the physical history of this pathological condition of the muscles to be noticed. The colour of the muscles, if they may so be called when adipified, is changed into either a dirty clay or a lemon colour, according to circumstances which are not fully understood. The adipified muscles in young subjects, appear to me to be of a much deeper yellow hue than those of old subjects. It may be remarked here, that fatty muscles offer considerable resistance to the scalpel on dividing them ; almost as much as when they are in their normal state.

Chemical analysis shows fat to be present in considerable quantity. The following abstract of a detailed analysis of fatty muscle by Cruveilhier is highly interesting, inasmuch as it strongly confirms the fact, elicited also by the microscope, that muscular tissue still exists in small amount in muscles which have apparently been converted wholly into fat. A muscle with its tendons weighing one ounce and seven drachms, on being cut into small pieces and macerated in cold water, gave half a drachm of oily matter. On boiling the residue for two hours, and submitting it to a strong pressure, it was reduced to a greyish substance weighing a drachm and a half, and resembling a portion of boiled muscle. The water being filtered and evaporated, four grains of gelatine were procured. The oily matter on the filter was found to contain four grains of crystalline fat, said to resemble adipocire, an ounce and two drachms of solid fat, and sixty-four grains of oily matter extricated by alcohol.* Had the above analysis been made with the tendons removed from the muscle, we should have been better able to appreciate the nature of the residual mass resembling boiled muscle. The analyses which I have made of portions of fatty muscle destitute of tendon and aponeurotic fibre, coincide in a great measure with that given by Cruveilhier, and they enable me to state that perhaps not more than one-half of the residue procured by him ought to be placed to the account of the

* Essai, &c. Vol. i, p. 188.

muscle. A portion of the *pectoralis major*, weighing one ounce avoirdupois, gave only two scruples of substance not fatty; and but forty-six grains of residue were obtained by me from a like amount of the *rectus femoris*, the rest being fat.

Gluge reports that he has obtained salts from fatty muscles in rachitic subjects, and Cruveilhier states that the fat obtained from adipified muscle is more inflammable than other fats; but I am not able to confirm his statement.

In conclusion, it is necessary for me to notice briefly two conditions of muscle which may be, and undoubtedly have been, mistaken for true adipification. The first is not unfrequently found in old decrepit individuals, and consists in the deposition of fat in the areolar tissue connecting together the fibres of the muscles. I have often seen this in the muscles of the back and of the calf in old persons, but never true adipification; for I have always failed to detect fat *within* the sarcolemma in such cases, and this we have seen to be the first and great change in the fatty transformation of muscle.* The second is seen both in young and in old subjects, especially in the lower part of the trapezius and the rhomboid muscles. It consists in the loss of the usual fleshy appearance of the muscles, and, according to my observations, is almost always associated with defective development of the altered muscles, the fibrillæ being smaller and paler, but still preserving their elemental structure unchanged. It was perhaps from the examination of instances of this last source of error, that Beclard was led to deny the occurrence of steatosis.

* Cruveilhier and Bichat have also pointed out the necessity of distinguishing this change from true fatty transformation of muscle.



