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SURGICAL STUMPS.

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THE

PATHOLOGICAL ANATOMY

OF

SURGICAL STUMPS.

BY

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Dr. Chauvel's Paper in the *Archives Générales de Médecine* for March, 1869, having been considered a valuable contribution to surgical knowledge, was translated for the Boston Medical and Surgical Journal. On asking for a few extra copies, the printer obligingly arranged the present form which those who wish to preserve the article for reference may find convenient.

Roxbury (*Boston Highlands*), *U. S.*
May, 1869.

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THE PATHOLOGICAL ANATOMY OF SURGICAL STUMPS.

WHILE two years attached to the Infirmary of the *Hôtel des Invalides,* we dissected and examined all the surgical stumps of those who died there during that period, and we propose to give a condensed statement of the results of our researches in the following paper, after a few words on the history of the subject.

History.—The first observations on the condition of surgical stumps date from the close of the last century. They were made in Germany, and form two inaugural theses. (Dezeimeris, Dict. de Méd.—Art. *Amputation.*)

In France Larrey took up these researches during his residence at the *Invalides.* The conclusions he arrived at may be found in volume third of his *Clinique Chirurgicale.* He insists mainly on the changes which take place in the divided nerves. He verifies the tumefaction of their extremities; from which he makes very delicate nerve-filaments issue to lose themselves in the cicatrices. He considers these filaments conductors of animal electricity. He meets with unusual reunions of divided nerves in three stumps of the arm; and sees in these nerve-anastomoses a provision of nature to prevent loss of nervous fluid by thus insuring its return to its source.

Changes in the osseous extremities did not escape his notice. According to him, when these serve as supports upon their whole surface, they enlarge, and the ends become flattened, like nail-heads. On the contrary, when not pressed upon, or when hanging free, the ends diminish in all directions and become rounded; the medullary cavity closes up, and the fibrous periostic tissue adheres to the cicatrix. Larrey sustains these views by seven autopsies.

Cruveilhier (*Anat. Path.*, iii. p. 755), under the name of *traumatic neuromata*, designates the bulbs usually developed on the ends of the nerves in surgical stumps. He attributes their formation to the friction and pressure necessarily endured by these parts, as such formations never occur when nerves are divided in continuity. Dissection shows, says he, that nerve-filaments spread out into the surrounding mass, and are soon lost; but the supposition of anastomosing loops is, he thinks, without foundation in fact.

Guthrie (*Comm.*, p. 75) relates that he once knew an operation to be proposed where tenderness of the terminal bulb of the sciatic nerve, after amputation of the thigh, had been mistaken for disease. Fortunately he was able to dissuade the patient. We have many times endeavored to feel the terminal bulb of the sciatic nerve in patients whose thighs had been amputated, but have never been able to find it.

Hutin (*Anat. Path., &c.—Mém. Acad. Méd.* 1855), long time Chief Physician of the *Invalides,* paid great attention to the condition of the several parts forming the stump. He studied the cicatrization of the arteries, finding them sometimes converted into fibrous cords, sometimes permeable to the very extremity, being simply obliterated by a long plug of fibrin, thick and discolored, without trace of organization.

He also examined with much care the nerve-bulbs, their appearance, structure, and termination. According to him, the filaments which issue from them are either nerve fibres, or simple cellular prolongations furnished by the neurilemma. The nascent bulb is formed by the retraction of the nerve substance within the neurilemma stretched by the cicatrix. At a later period it becomes more or less increased in size by addition of fat and hypertrophy of the neurilemma. He declares that re-union, end to end, of divided nerves does not exist in reality. By chance, nerves may be found involved in common fibrous tissue, and thus apparently re-united, but there is never a true reunion of their substance.

The bones, he says, soften at their extremities; their walls contract; and the medullary cavity closes by a calcareous deposit in the cicatricial tissue. This substance in excess often forms prolongations, spines, and considerable masses, which, by pressure on the soft parts and nerves, cause severe pains to patients.

M. Notta has endeavored to show that the fibrous cord continues even to the cicatrix, and what is usually thought to be the obliterated artery is in reality only inodular tissue formed by the cicatrization of a fistula produced by the thread of the ligature.

Lobstein (*Anat. Path.*) calls attention to the mucous bursæ sometimes occurring on the osseous extremities in stumps; formed there, he thinks, by the repeated frictions these parts are liable to.

Legouest (*Chirurg. d'Armée*) admits the re-union of the nerve-extremities end to end. He describes growths on the ends of bones, from specimens in the collection of M. Hutin, and gives figures of some of the most remarkable. He points out a different result in this respect, after disarticulations, where the bones, he finds, become atrophied.

Alphonse Guérin (*Nouv. Dict. de Méd. et de Chir. Prat.*, ii. p. 87) doubts the propriety of regarding the nerve-swellings in stumps as a disease like neuroma, whose symptoms they are far from presenting.

We may mention, also, as bearing upon our subject, a notice of the atrophy of arterial walls by Maurice Raynaud (*Nouv. Dict. de Méd. &c.*, iii. p. 232); and Nélaton's view of the transformation of an artery into a firm ligamentous cord (id. iii. p. 172). He regards this as constant after a section of a vessel, and as the normal mode of vascular obliteration.

Researches.—Our own conclusions are based upon thirty-two cases, as follows:—

Amputations, thigh	upper third,	3	
	middle "	4	
	lower "	4	11
" leg	. . . . .		8
" arm	. . . . .		6
" forearm	. . .		1
" hand	. . . . .		1
Disarticulation, ante-scaphoid	. .		1
" shoulder	. . .		4
			32

In a general view, the form of the stump varied with the member amputated. In limbs of one bone (thigh, arm) the stump always tended to conicity. This was produced by muscular retraction, and sometimes had been increased by wearing an artificial limb. The skin was also retracted, and the cicatrix in this way so drawn upon as to keep up the tendency of the bone to protrude.

There was less conicity in members of two bones, as the shorter muscular fibres were fixed to the bones near by, and the skin, held down by more compact cellular tissue, had less freedom in retraction.

On first section of a stump one is struck by the abundance of fibrous tissue, dense and firm, enveloping the osseous extremity. It attaches muscles, nerves and vessels to the cutaneous cicatrix, and thus serves as a common bond, uniting all these dissimilar parts. Its volume is increased at the expense of other substance lost by the operation.

The actual state of the stump in our cases varied according to the disease to which the patient succumbed. If he died of a constitutional affection, cancer or tubercle, the stump shared the atrophy and emaciation characteristic of the last stages of such diseases. Its skin was then dingy and sallow, the muscles were atrophied, and all the parts infiltrated with serum. If, on the contrary, the patient continued in good case, the stump remained well nourished, while a deep layer of fat thickened the skin and enveloped the thoroughly degenerated muscles.

State of the Cicatrices.—Can the method of operation be made out by the form and position of the cicatrix? Not easily, says M. Legouest and rightly. In almost all the cases we examined the circular method had been practised; and, nevertheless, in our eleven amputations of the thigh, for example, we found six circular and five linear cicatrices, almost invariably drawn a little backwards and inwards. The cicatrix, in short, varied according as the union was wholly or in part by first intention, or interrupted in any way in its usual course.

In two disarticulations of the shoulder, however, the cicatrix clearly indicated the method employed, that of Larrey in the first, of Dupuytren in the second. In the amputations of the leg and arm, the method could not be ascertained by the cicatrix.

Cicatrices resulting from the same method not only varied in form and extent, but also in their nature and color; sometimes smooth, dull white, and quite thin, at other times violet, rugous, deeply injected and of great thickness. Generally the cicatrix adhered to the end of the bone by short interwoven fibrous bands. Occasionally these bands were elongated, and formed a mucous subcicatricial bursa. We met with such a bursa three times.

State of the Muscles.—Fatty degeneration of the muscles has been described by all writers. It was recorded, with the atrophy that accompanies it, in almost all our observations. Naturally, a muscle unused loses its powers and normal structure. This is a gradual transformation, and requires considerable time. We met with it in all degrees, both in different subjects, and in different muscles of the same stump. In some the change was so slight that the color, volume, and tenacity of the muscle were as of healthy tissue; and the loss of striæ, if any, in its fibres, and commencing granular condition, were ascertainable only by the microscope. In others the degeneration was so complete that the naked eye could perceive only a shiny, bleached, and almost fluid mass, breaking down under the fingers; while the microscope revealed large globules of fat, and only here and there vestiges of primitive tissue. In these results not only age had an influence, but nutrition also, in its bearing upon the general health and free circulation.

Nevertheless, it must not be thought that every muscle divided in amputation must of necessity become atrophied and fatty. Sometimes when thus deprived of one point of attachment the muscle soon begins to acquire others. It fixes itself upon the new formations of bone, or finds a point of support in the common fibrous tissue to which itself contributes a portion, and, in as far as its nerves are not destroyed and its functions are called into action, we find its volume and structure preserved. We do not state this upon hypothesis; five of our observations demonstrated the truth of the assertion.

We need not add more upon fatty degeneration, as it has been studied for a long time, and is now well understood.

State of the Vessels.—Many and very important works have been published on the cicatrization of vessels cut in continuity, having for their special object the mode of occlusion of arteries. The solution of a problem in pathological anatomy has not been so much sought for as the surest way to obtain a closure of the vessel. Ligation continues still the usual practice in amputations.

Our observations have been confined to stumps long after cicatrization had finished, and therefore we will now discuss only the following points:—

Does the fibrinous clot-plug continue indefinitely in the vessel?

Is the clot susceptible of becoming organized and of establishing with the vascular wall intimate adhesions, fully organized and traversed by vessels?

Can the clot-plug be completely absorbed;

and in such case can the walls of the vessel unite so as to form only a fibrous cord?

Does the arterial wall become thin, so as to resemble that of a vein?

M. Hutin, in his remarkable work, records the persistence of the clot-plug, filling the cavity of the vessel, long years after the amputation. This we have met with nine times in thirty-two cases, or in one more than a quarter part. In all these cases the clot was fibrinous, whitish, firm, and formed in concentric layers—variable in dimensions and extent. It was sometimes prolonged up to the first important collateral from the very extremity of the artery; at others no collateral marked its upper limit, while below it was lost in the walls of the artery so closely united as to transform the vessel into a simple fibrous cord.

In none of these cases did the clot-plug present any traces of organization. Microscopic examination showed only fibrin more or less disaggregated, never any vessels. Sometimes the adhesions to the arterial walls were very intimate, but more often the clot separated readily.

The absorption of the clot-plug, with the intimate and complete fusion of the walls of the artery, which was thus transformed into a simple fibrous cord, was met with more frequently. We noticed this in fourteen, or almost half our cases. This transformation varied greatly. The adhesions were rarely abrupt; and the vessel seldom maintained its normal calibre upwards. Accompanied by a vein still more feeble than itself, and proportioned to the parts to be nourished, the artery at once began to lose its dimensions. As it approached the stump it contracted, sometimes gradually, sometimes suddenly after having given off an important collateral. This diminution of calibre was noted fifteen times in thirty-two cases, and this, too, where the anatomical situation permitted the easiest demonstration of its reality. It was thus that in amputation of the arm at the upper third, and in disarticulations of the shoulder, the axillary artery, after having furnished scapulary branches, shrivelled and became a true arteriole. There was no further occasion for it.

In one instance only have we noticed the vascular wall thinned, resembling that of a vein. Oftener, four times, we have found it notably thickened.

Besides these two modes of termination, sometimes the artery continued permeable even to its extremity, without clot-plug or fibrous terminal cord. Then the calibre either gradually diminished to the point of closure, or, on the contrary, remained unchanged, presenting the appearance a vessel should have immediately after ligation, i.e., a true *cul-de-sac*. When the latter occurred, a cluster of arterioles was not infrequently found arising from this *cul-de-sac* to spread themselves into the common fibrous tissue. We have met with this permeability eight times, and in half of these cases the calibre of the vessel remained unaltered to its extremity.

Like M. Hutin, we have very seldom met with a fibrous cord which prolonged the artery to the cutaneous cicatrix, or that which M. Notta thought to be an inodular band, corresponding to the former passage of the ligature of the vessel. We have always found the artery itself terminating at a distance from the cutaneous cicatrix, varying according to the greater or less hindrance to the vessel's retraction. Cut in the middle of the thigh, the artery will retract strongly within its sheath. It preserves its original position only when retained in it by fibrous adhesions.

We have not found atheromatous degeneration when present more frequent or more advanced in the arteries of the amputated member than in other parts.

State of the Veins.—Cicatrization of the veins has not been studied with the same care as that of the arteries. The direction of the sanguineous current and the presence of valves opposing its return, render, in fact, venous hæmorrhages less frequent than arterial. If a vein is tied, obliteration seems to take place by adhesive phlebitis, forming a clot which is afterwards absorbed. The walls of the vessel then immediately fall together, and are soon completely united. Thus, at least, we have always found it in our investigations.

State of the Nerves.—Nerve-anastomosis, maintained by Larrey as a constant fact, and denied by Hutin who saw in it only a simple contact, has never appeared under our observation. Once we saw an internal cutaneous nerve seeming to be confounded by a loop with a median in the same terminal enlargement, but it was only a semblance, a simple juxtaposition of the terminal neuromata of these two nerve-trunks.

Sometimes two nerves in contact were thus commingled in the terminal tumor. Sometimes a whole cluster of nerves were likewise englobed in one neuroma, as was especially seen in disarticulations of the shoulder. But even in these cases there never was an anastomosis. At one time the separate neuromata were intimately united to form one single mass where each, nevertheless, could be distinguished. At another time these neuromata, although buried in a common adipose tissue, had no connection whatever between themselves. We met with each of these conditions four times in eight amputations, of the arm and at the shoulder-joint.

We may conclude, then, that real nerve-anastomosis is very questionable; that even apparent anastomosis is very rare; and that, for the most part, the nerves have isolated terminations, although their extremities be enclosed in the same fibrous cicatricial tissue.

Larrey first demonstrated the termination of the divided nerves of a stump in a tubercle more or less voluminous and rounded; from which, according to him, nerve-filaments diverged to conduct the animal electricity to the cicatrix.

Now, nerves for which there is no longer any use, present to the naked eye normal dimensions and aspect; and, on section, we almost invariably found them healthy under the microscope. But in a certain number of cases we met with the following state of things:—

On longitudinal section three layers were readily made out:—1, the external, thin and white, formed by the neurilemma, a dense connective tissue; 2, the middle, yellow and often increased by adipose matter as it approached the terminal protuberance, being composed of a very loose connective tissue, with interspaces filled with fat; 3, the central, consisting of a white cord, variable in thickness, and dividing so as to be lost in the terminal bulb. This cord was composed exclusively of unaltered primitive nerve-fibres.

This condition we have only seldom fallen in with. Is it a cadaveric phenomenon, the result of an alteration of a nerve after death? Nothing appeared that could give rise to such a supposition ; and there were no peculiarities in the subjects adequate to the solution of the question. The autopsies were made at equal intervals after death. We must add, however, that we have met with this condition only in obese individuals, in stumps loaded with fat, and where the muscles were fatty in the highest degree. It gradually diminished upwards, and entirely disappeared four or five inches above the terminal neuroma.

We find that all authors (Larrey, Hutin, &c.) lay stress upon the club-like termination of nerve-cords cut in amputation—a result differing from that obtained in experimental nerve-sections, where the central end of the divided nerve is found to retain nearly its normal size to the point of cicatrization.

In concurrence with M. Hutin, we ought to state that this protuberance is not constant. In our examinations it was wanting twice in amputations of the thigh, twice in the leg, once in the arm ; and this, too, sufficiently long—five years or more—after the operations.

In all our other cases the nerves have presented these little tumors; variable in development, yet always in proportion to the size of the nerve-trunk. Eight times, according to our records, they were not remarkable; sixteen times, they were voluminous. We shall see presently whether it is possible to explain these variations.

Four times we have met with many such tumors developed along the course of the same nerve near its extremity; once on the tibial saphena, once on the external popliteal sciatic, and twice on the median; without anything to explain the peculiarity.

In general, the protuberance is, as it were, a continuation of the nerve on which it is developed; sometimes, however, it seems to be merely in apposition.

Each nerve appears to have its special and very distinct neuroma. This should be so, necessarily, when their extremities are apart from each other. But the same condition is found also when nerve-trunks are divided at a point where they are brought quite together, as in the axilla, for example. Besides, it is not astonishing that all such neuromata, naturally in contact, should, though distinct, be englobed at their inferior portion in a common fibrous mass connected with the cicatrix. The fibrous bundles of hypertrophied neurilemma adhere, interlace, and form this common portion of the protuberance.

In a single case of disarticulation of the shoulder, we found the extremities of the nerves so lost in the common mass that it was impossible to separate them or to distinguish their particular bulbs.

These protuberances generally had an elongated shape, in the direction of the trunks of the nerves. They varied greatly in size, even on the same nerves, under apparently identical circumstances. In eleven stumps of the thigh, the sciatic terminated seven times in quite large tumors, once in a small one, and three times without enlargement.

Seven patients used, in walking, the padded long peg (cuissard), having its principal point of support at the ischium, and being retained in place by a leather belt around the pelvis. In six of these the sciatic bulb was very large. In one there was no terminal neuroma.

The remaining four used crutches. Of these, one had a very large, one a very small, and two no apparent tumor of the sciatic. Almost all the operations dated far back—the most recent as far as 1854–55.

It would seem, then, that the apparatus used in walking had some influence in the production of these swellings; how much we shall soon see, and how it may be understood and explained.

The position of these tumors varied with that of the nerves on which they were situated, and they were greatly modified by their connections with the neighboring parts. When the nerve was in the midst of the cellulo-adipose tissue, loose in surrounding parts, as the sciatic, the axillary plexus, &c., we found the neuromata free also in the fatty mass, and attached only to the cicatrix by the lower extremity. When, on the contrary, the nerves were fixed at the point of division, as, for instance, the radial in the humeral groove and by external intermuscular aponeurosis, or the external popliteal sciatic at the neck of the fibula, then the terminal protuberance was often found englobed in the fibrous cicatricial tissue, and at times inseparable from it.

These tumors presented to the naked eye a smooth, pearl-white surface, and elastic consistence. Free throughout most of their extent, they were almost always attached to the cicatrix by fibrous prolongations from their inferior extremities. Once only have we found the tumor completely free, without any connection with the fibrous tissue.

So great was their elasticity that it was difficult to cut them with scissors, or even with the scalpel. They presented a rosy-white, cut surface, with yellowish or at times still whiter and glaring patches at the centre and borders, or over the mass. In other respects these tumors were so variable that it is impossible to give a general description applicable to all. Nevertheless two portions could ordinarily be made out:—1, the exterior envelope, the continuation and manifest expansion of the hypertrophied neurilemma, which could be traced onward even into the fibrous cord attached to the cicatrix; 2, the central portion, which appeared to be rather the expansion of the nerve itself and of its tissue more or less modified.

We have said that the neurilemma spread out disunited bundles over the tumor, to form its external layer. Farther on, these bundles again approached each other, and condensed to form a simple fibrinous cord, which disappeared in the common fibrous tissue. Very rarely, these bundles continued, as it were isolated, even to their union with the cicatrix. But we have never met with the nervous fibrils which Larrey regarded as the conductors of animal electricity, and which M. Hutin also has sometimes observed.

Are these nerve-bulbs, which Cruveilheir described under the name of *traumatic neuromata,* in reality tumors of such a nature? Are they true nerve-tubes in their structure, or simply, as Legouest and A. Guérin thought, the result of hypertrophy of the connective tissue? We observe in the first place that in external characteristics, form, color, aspect, consistence, &c., these tumors greatly resemble common neuromata. True they usually differ from the latter in the symptoms produced. Spontaneous, sharp, and sometimes insupportable pains are constant attendants on pathological neuromata. In stumps, on the contrary, so far as we have been able to observe them, such pains are rare compared with the frequency of traumatic neuromata. But the histological structure is the same in both, and this settles the question. Microscopic examinations which we practised in almost all these cases, and which MM. Paulet and Villemin kindly repeated, enable us to affirm in all of these tumors the presence of true nerve-tubes.

Two elements concurred to form these bulbs—the compact fibres of connective tissue, and the bundles of nerve-fibres. On the surface of the exterior appeared only fibrous tissue, arising from the hypertrophied neurilemma which enveloped the tumor. The internal part, or the tumor properly so-called, was formed of very dense connective tissue, in which meandered bundles of nerve-fibres, more or less abundant, and more or less in apposition. Infrequent at the periphery, these nerve-bundles became so numerous in the central tract as to suggest a local development of nerve-fibres.

These tumors were, then, true neuromata, as Cruveilhier and Hutin considered them.

We have never seen nerve-fibres pass the limits of the tumor. The ligamentous cords and the loops which attached it to the common fibrous tissue were exclusively formed of bundles of connective tissue, re-united in one instance, isolated and distinct in another. Even when there was no terminal bulb, the fibrous cord, almost uniformly present, was never composed of anything but connective tissue.

We may now ask what is the mode of formation of these protuberances, and what causes tend to their development. M. Hutin gives the following explanation :—" the nascent tubercle is either formed by the crowding back of the nerve-substance into the neurilemma as the latter is drawn upon by the cicatrix, to be afterwards augmented in volume by the addition of adipose matter; or else it is due to increased thickness of the cicatricial tissue, which continues to expand between the several nerve-threads within the common neurilemma."

This explanation appears to us very reasonable and perfectly admissible. We believe, however, that he is describing a mere phenomenon of inflammatory irritation, especially when we take into account the considerable development of fibrous tissue in the extremity of a stump. Divided muscles, vessels and nerves undergo a certain degree of inflammatory irritation during cicatrization, and this irritation induces hypergenesis of the connective tissue. There is not, nor can there be, a direct union between the extremity of a divided nerve and the adjacent tissues; but perhaps the development of a neuroma may be proportionate to the latent irritation which always remains, for a longer or a shorter time, in the extremity of an amputated member. We would like to study this cicatrization of nerves at successive periods, to ascertain at what time the protuberances arise, and at what moment they cease to grow, but as yet we have met with stumps of long standing only. Hypergenesis of the connective nerve-tissue, of the neurilemma, and of the perineuron, is, in our opinion, the primary cause of the formation of these neuromata.

The nerve-tubes are thus distributed in bundles through the new tumor, and remain there without alteration.

Cruveilhier asks if friction and pressure, to which the extremities of the nerves in a stump are almost inevitably exposed, are not the active cause in the development of traumatic neuromata.

Analyzing in this point of view our eleven amputations of the thigh, we see that of seven who used the stuffed long peg, six presented very large neuromata of the sciatic. Of the four who used crutches, two only had medium-sized neuromata, and two almost nothing. It would appear from these facts that when the stump was wholly free, there was much less tendency to the production of neuromata. Although the long peg, in fact, ought not to take its bearing at the stump if properly stuffed, still there is an evident necessity, in order to make walking easy or even possible, that the periphery of the thigh should be in contact with the apparatus. Hence a certain dragging and a pressure which tend to force back the soft parts towards the axis of the member. If, on the contrary, a badly made apparatus allows a displacement of the stump at each movement, the chafed parts soon become painful, and walking impossible. All these inconveniences of the long peg are increased necessarily when the remaining portion of the limb is very short, for which reasons two of the three whose thighs were amputated at the upper third, used crutches exclusively. But why in amputations of the leg, when the patient used a short peg (pilon) which left the stump entirely free ; in disarticulations of the shoulder, where the stump was not enclosed in any apparatus, for our patients seldom used any in these cases ; why were these neuromata, then, as one may truly say, constant and almost always very large ?

Even if the extremities of the nerves were found englobed in common fibrous tissue merely, still some authors would insist upon the influence of pressure. But even in this our facts appear contrary to such hypothesis. The neuromata were most commonly wholly free, in the midst of other parts, and buried in very loose large-celled cellulo-fatty tissue. We must therefore seek another cause, and one whose action may be as constant as the effect attributed to it.

May we see in the formation of such tumors a provision of nature for the protection of the ends of the divided nerves? To justify such an hypothesis the nerve should be enveloped in this fibrous shell entire, and not separated into bundles diverging into connective tissue. And further, such a fibrous crust would rather produce the opposite effect, for the extremity of a nerve free in the midst of soft parts, would escape with greater certainty the action of foreign bodies than a large, hard, and elastic tumor, offering a greater resisting surface.

We conclude, then, that the development of neuromata is due to inflammatory irritation which follows the operation and accompanies cicatrization, but that subsequent pressure and friction are not without influence on their enlargement. It is to this latent and prolonged irritation that we must attribute the hypergenesis of the connective tissue which constitutes the neurilemma. The nerve-fibres undergo no alteration.

State of the Bones.—The opinions of Larrey, Hutin, and Legouest, were cited above, in our History of the subject. We proceed with our own conclusions.

The primitive phenomena which follow a section of a healthy bone are those of slight ostitis, with increased vascularity; the formation of fleshy projections; and more often an exfoliation of superficial layers from the surface of the section. Then the fleshy projections develope, run together, and, becoming calcareous, form osseous beds which close up the medullary canal opened by the operation.

Often at an autopsy of a stump the bone no longer exhibits a natural condition. But a distinction must be made between amputations in contiguity and those in continuity. In the first instance the bone, not submitted to traumatic lesion, takes on only that degree of inflammation which is necessary to remove its articular cartilage, and to contract adhesions to the neighboring parts. It is this indispensable elimination of cartilage, sometimes a very slow process, that greatly retards cicatrization in these operations. The subcartilaginous parts of the head of the bone alone inflame, and the epiphysistic periosteum remains sound, if all proceeds as desired. This process being finished, the head of the bone becomes atrophied with the soft parts, sometimes to such a degree that it is said that the femur has been known to terminate in a point, after disarticulation at the knee, and thus to render the use of ordinary artificial apparatus very difficult.

As to disarticulations, we have had chiefly stumps at the shoulders to examine, and all of long standing. In all four, the stumps were well nourished, and the shoulders were not sensibly atrophied. In three the shoulder-blade was natural. In one alone the glenoid neck was sensibly flattened, and slightly reduced in size. The only constant modifications were of the glenoid cavity. We always found it deprived of its articular cartilage, flat, or slightly convex instead of concave, and covered with a fibrous tissue not adherent to the cicatrix. The glenoid fibro-cartilage had disappeared, or become confounded with the fibrous tissue. The latter was only slightly adherent to the bone. The glenoidal surface was smooth, flat, and without marks of inflammation.

In these cases, it is true, the stump was not submitted to any influence powerful enough to effect great modifications in the bones. A simple cover of leather served to protect the shoulder from direct blows, and no other artificial appliance was made use of. The soft parts abundantly covered the underlying bones, and produced no pressure upon them.

When the bones are required to furnish a point of support to a member the modifications are more grave. In partial amputations of the foot, cicatrices often ulcerate, and the subjacent bones inflame, and become carious, or necrosed. In an autopsy of an ante-scaphoid disarticulation we found ulcerations of the soft parts, caries of the bones, and vegetations surrounding the altered surfaces. There was at the same time a partial luxation of the foot upon the leg; the astragalus was carried far in front, its posterior portion only being in contact with the tibio-fibular articulation. Walking had become impossible on these parts, and the patient used the short peg (pilon). The muscles of the leg were wholly adipose; and the tendons themselves had lost their pearl white appearance, had become fatty in their turn, and were easily broken.

In amputations in contiguity the bony extremities are more apt to inflame and to change in form and size from ossific productions or new ossiform formations—the result always of a certain degree of inflammatory irritation.

The following were the results in this respect in our series of observations: In eleven amputations of the thigh, the extremity of the bone was in seven instances considerably tumefied; twice it was not very sensibly modified; and twice no change could be discovered.

According to the place of amputation we found—of three at superior third, all considerably enlarged; of four at middle third, two considerably, one slightly, and one of natural size; of four at inferior third, two considerably, one slightly, with bony crests, and one of natural size.

Thus hypertrophy of the bony extremity by the addition of new layers, or the production of crests and ossific concretions, is to be found very frequently in amputations of the thigh, especially at its upper third.

As to the leg, we always found that the tibia had undergone very slight or quite inappreciable changes in form and volume.

The fibula was uniformly dwindled, more or less pointed, and drawn towards the tibia.

In the arm the results were about the same. The humeral extremity was not sensibly modified. Now and then there were ossific crests, or slender projections on its edges; quite as often it was slightly shrunken and its walls compressed together.

From our rapid sketch it would appear reasonable to adopt the conclusions of Larrey; that when the bone does not serve as a point of support, or sustains no pressure, as in stumps of legs, arms, &c., it gradually tends to become atrophied; while on the other hand, under opposite conditions, as in stumps of the thigh, its extremity becomes enlarged and club-like.

But we can admit only a part of the first proposition of Larrey. Instead of asserting with that illustrious surgeon that the end of the bone shrinks, flattens, and atrophies, our observations simply warrant us in saying that it usually preserves its natural volume, or only becomes slightly atrophied, or at times thinly covered with crests or bony accretions.

As to Larrey's second proposition—we remark that of two who suffer amputation of the thigh, one of whom walks with the long peg, the other with crutches, the first only ought to have a club-shaped bone, for he alone has the point of support at the extremity of the stump. But in our eleven amputations of the thigh, three used crutches exclusively, and yet these three presented large tumefactions of the femur. Of the eight which remain, four only showed such enlargements, and all these used the long peg; that is to say, were most exposed to frictions, dragging and pressure.

It seems, then, difficult to attribute these osseous deposits to the mechanical influences invoked; and yet, when one sees that these productions form almost exclusively on the thigh, and never, or very rarely, on other parts, he finds it difficult to believe that irritation or latent inflammation is the principal cause, since this should act on all kinds of stumps alike.

There is, however, a special reason for this irritation in amputations of the thigh. Stumps of thighs, as we have said, have the greatest tendency to conicity. In spite of all precautions, the consecutive retractions of the soft parts are continually forcing forwards the thigh bone. This bone, in this way becoming thinly covered and badly protected against exterior influences, is now more subject to pressure and friction. Thus a continued source of latent inflammatory irritation, whence the production of new osseous layers, is readily comprehended.

These ossific concretions take on all possible appearances, and give to the ends of the bone shapes as different as those of the stumps themselves. Sometimes there are only slight projections or crests of a few lines in height; sometimes, again, for a considerable extent there are very regular layers, which double or triple the thickness of the bony walls. In some this transformation does not exceed a third or half an inch; in others the hypertrophy rises three to five inches above the surface of the section, and gives the bone the almost exact form of a pestle.

When the medullary canal closes, it is almost invariably effected by a layer of new bone. We are wholly ignorant at what precise moment this takes place. We can only say that in three of the eleven amputations of the thigh we found this obliteration incomplete; an exception still more rare in the tibia and fibula. The firm, rounded passage which led into the medullary canal, varied in diameter from one to three-tenths of an inch, or thereabouts. Surrounded by a very thin and fragile bony rim corresponding to the centre of the osseous section, this passage was closed up by a dense, almost cartilaginous tissue. The operations dating back twelve or thirteen years, there seemed little probability that the obliteration was of recent occurrence.

When the medullary canal is closed, as

it usually is, the thickness of the bony layer closing it varies from less than a twentieth to more than half an inch. This layer is often so thin as to be quite transparent, but always so dense, hard and resisting that it cannot be pierced by the scalpel.

All these osseous layers of new formation were, in fact, composed of compact tissue, hard as ebony. Ordinarily no decided line of demarcation existed between the old bone and the new accretion. Perhaps, nevertheless, the new tissue may have had a little deeper color, while tending to a characteristic greyish tint, especially in the central portion of the growth.

Unfortunately, we did not examine this new tissue with the microscope, to determine whether it was formed of true bone or of mere calcareous deposits ; but its mode of formation, its aspect, and its structure, all led us to the former hypothesis.

The surrounding fibrous tissue gave to these osseous productions a periostic covering which adhered intimately. Vessels traversed it and passed into the bone. It is the internal layers of this fibrous tissue that become ossified by the latent irritation, which follows operations and is induced by shocks and friction.

In members of two bones (leg, fore-arm), the bones, being no longer retained apart, tend, after section, towards each other at their extremities. On them osseous vegetations were less abundant and less developed. We have seen the shrunken fibula inclining towards the tibia, and united to it by strong fibrous bands ; and even, in one case, by a true, compact, and very resisting, osseous bridge.

Such were the principal transformations we met with in Surgical Stumps. We regret that we had not a larger field and more varied observations to render a study of the subject at once more complete and more interesting.