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LECTURES ON AMPUTATION,

AND ON THE

*Nature, Progress, and Terminations of the
Injuries for which it is required.*

(Delivered at Sydenham Coll. Med. School.)

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LECTURE XX.

SUMMARY OF RESULTS.

PART I.

Object of the present series of lectures stated. How endeavoured to be attained. Necessity for cure and discrimination in the materials employed. These forming the elements for any judgment upon the questions involved in amputation, and by which they are to be decided. True objects of amputation classed and defined. RESULTS on the system, of those forms of chronic local disease for which amputation is adopted. Results of the injuries of civil life for which amputation is usually performed. Results of the injuries of military life, in like manner treated to the end without operation. Modifications in the results induced by varying conditions, moral and physical. Causes, or diseased actions, which lead to amputation under different circumstances, compared with the causes of death. Causes of variation in the relative proportion of amputations required, and of deaths occurring while cases are under treatment.

I PROPOSE in this concluding lecture to give a summary of the principal results of the inquiry which you have followed, step by step, into the nature, progress, and terminations of the more complicated forms of injuries of the extremities, when submitted to treatment; and, finally, of the results of amputation, when performed at primary, intermediary, or secondary periods, by different operative methods, and under different influences, physical and dynamic. I purpose to bring before you at the same time, in a condensed form, the principles of practice these results are calculated to establish, and the legitimate

bearing of the facts upon some of the leading doctrines of the present day in relation to amputation, its relative expediency and efficacy at different periods, and the treatment of grave and complicated injuries of the extremities.

In commencing this series of lectures, I proposed to myself an object certainly not hitherto attained. I believe that you will find an inquiry, such as we have been engaged in, similar in aim and scope, and carried out in all its details, had not previously been attempted. But if I thus seem to claim any merit for the attempt, I beg you to believe that my labours were undertaken with no feeling of overweening confidence, but with a full consciousness of all the difficulties of my task. I have been impelled chiefly by a strong conviction of the importance and scientific interest attached to the subject. And on this ground have I ventured to engage at such length your attention. I must beg you also to believe that I recall the circumstances at this moment, conscious that my best efforts in this almost untrodden path have fallen far short of my wishes, and of the exigency of the subject. Yet the opportunities I have had of studying the effects of injuries and operations have been unusual, and seemed to justify the attempt.

Many years a principal medical officer in two services, during which I was entrusted alike with the duties of the field in every action, and with the organisation and direction of all the hospitals required for the sick and the wounded of the auxiliary forces engaged, it was not less a pleasure than an imperative duty, to devote every hour not actually spent in the field, or on the line of march, to the study and treatment of the cases, medical and surgical, filling large hospitals, and for the efficient care of which I was justly held responsible. Perhaps I am indebted to the flattering confidence which entrusted me with such heavy and responsible duties at an earlier period of my professional life, than in ordinary circumstances is usual, not only for enlarged opportunities of studying disease and injury in all its aspects, but for that zest and devotion to the labour it entailed, which I always felt and believed to be the only adequate return I could make.

Under these circumstances, at first insensibly, and later, as the result of continued efforts directed to that end, I found materials accumulate of the most valuable kind, consisting of records of cases, experiments, and observations, and of preparations of morbid structures, which, in their number and varied nature, might seem surprising, collected as they were in the course of the most arduous services, during the late civil wars of the Peninsula; unless it were stated, as it is my pride at all times to acknowledge, that it was my peculiar fortune in these duties and labours to be aided and seconded by a most zealous and indefatigable medical staff.

To Mr. Gannon and Mr. Blair, in Portugal; to the former also in Spain; and to Drs. Johnstone and Dolce; to Messrs. Sholl, Dorset, and A'Beckett, Staff-surgeons in the Force, and to the Medical Officers generally, I should be ungrateful, indeed, if I alluded to the collected scientific results obtained from the numerous hospitals of the two services (and be supposed to claim any merit from them), if I did not, even at the cost of a digression like the present, give them back the ample share which is so justly their due. The results and the facts, embodied in these and other lectures delivered here, were collected under my directions, and placed in my keeping, only by their efforts united to my own. I consider them held in trust, therefore, not to be used for my own exclusive benefit, nor without due acknowledgment.

One of the peculiar difficulties I have felt throughout these lectures, I explained to you in my last, viz., that I had felt compelled to lead you through the *steps of the inquiry*, and to furnish the *materials* for the investigation, since I could not refer you to any already existing, instead of confining myself, as I should otherwise have done, to *results* only. My object in this concluding lecture, therefore, is to separate from the mere process of inquiry the *results* actually obtained, and present them to you as unencumbered by details as the nature of the subject will permit, and in a clear and lucid order.

The object of the inquiry through which I have conducted you in these lectures, was to ascertain and determine what were the *effects of amputation upon the system*, uncomplicated by disease or injury, and the *true causes of mortality*; the *effects of amputation when the operation was superadded to the forms of pre-existing disease, or injury*, for which it is most usually performed; and, lastly, what were the *circumstances and conditions* moral, dynamic, and physical, which determined the *relative degrees of mortality or success* found to mark the operation in practice.

If the object were attainable, it is obvious that in proportion to the certainty and precision with which these bases were fixed, would be the accuracy with which we could predict the result of amputations, according

to the predominant conditions and influences, and determine the safest practice to be pursued, whether the surgeon should rely upon treatment or resort to amputation; and if the latter, at what period in what mode, and under what conditions, the operation could most successfully be performed.

That by any means a power could be obtained of determining with perfect certainty, in each *individual case*, that any given result would follow a given course pursued by the surgeons in reference to it, is not to be imagined. Such fixed results, however, attainable in the mass, are clearly beyond our reach, in the individual or in any fractional portion, except when our materials are formed of inert matter, subject to no variation in the laws by which each part and the whole are governed. Each part of the mass, that is, each individual of the human species presents, on the contrary, an infinite variety of conditions and powers of resisting, of reacting upon, and of modifying the influences to which they are subjected. A law that will produce an unerring and unvarying result upon a thousand, would in that number produce an almost infinite variety of results if the individual parts were each analysed.

It is thus evident that we cannot determine a rule of practice, or a principle of medicine applicable to the whole, by the observation of individual cases, and deductions from one or two of these must not be relied upon, for they lead to the most contradictory, vacillating, and erroneous conclusions. This only can be obtained by combining the observation and the records of a large number, arranging them according to predominating influences, and analysing the results thus ascertained. The first classification must be founded upon the largest and broadest characters, and gradually in the spirit of analysis, subdivided in reference to the minor characteristics and differences down to the last link, comprising the details of an individual part. A true principle can only thus be legitimately developed, or with certainty determined—not liable to change, because fixed on a basis of facts, sufficiently large to give it solidity—not liable to be upheld one day and subverted the next by the breath of a bold assertion, because a superstructure thus raised can only be successfully assailed by a doctrine equally largely based, all its parts inviting and bearing the test of scrutiny and analysis.

Principles, then, let me repeat, are calculated to give certainty to the practice of medicine *applied to the mass*; no stretch or power of human intellect can determine with equal certainty the *results of individual cases*. By applying and testing principles by their effects on the mass, we gain the same relative power conferred by a microscope; everything, to the minutest action and effect, is enlarged in its proportions to such a vast degree, that we can appreciate the smallest

resemblance and differences, thus rendered gross and palpable. Statistics may better be illustrated by reference to the manipulations of a scientific chemist, ten thousand fractional parts aggregated into one, gives a mass sufficiently large to produce appreciable and definite results in the crucible, each of which, from their larger proportions, can be submitted to various tests, until their real nature is determined with precision and with the utmost certainty: whereas the same process by no art can be successfully applied to an unit, or a grain's weight, still less can any intermediary result be tested and analysed in various ways, under different conditions and influences, until a conviction of truth and accuracy in one fixed product is obtained.

In this spirit, upon these grounds and on this principle, should statistics be applied to medicine; and thus applied and understood, they form a means of advancing science, yielding in none, hitherto applied in efficiency, value, and importance. Neither certainly can they boast of any exemption from labour: they are not to be approached carelessly, or to be taken up by snatches, and again laid down. To elaborate a series of conclusions on which general principles may be constructed, requires long and patient efforts to collect facts, which form the minute particles to be aggregated. To form a sufficient mass for the crucible, they must be faithfully observed and discriminated, otherwise fragments of different materials are added to the matter to be tested, and falsify the whole of the results. The facts are, so many grains of gold, each requiring the same care and discrimination in its collection and elimination from all earthy or extraneous matter in connection, which may often bear some analogy, and yet be essentially different in character and properties. When these separate parts or particles, by a continued series of efforts, amount in the aggregate to a sufficient mass to admit of analysis, the results must be submitted to various tests, by modifying the circumstances, by the combination of various other elements, &c. This process in itself is one requiring the utmost care and conscientiousness, otherwise, however carefully selected may have been the materials, the results may be full of error.

I have here given you a description of my own task, and of the various steps of the inquiry we have prosecuted together; the conclusions I have laid before you were none of them foregone: I placed the materials I had been years in collecting into the crucible before you, analysed them even to their last elements, and then declared to you the legitimate results. To thus submit materials to this process, it was imperative that I should myself have collected them, not that others might not have performed this part better and more amply, but that no such facts, in complete series, with all their va-

rious characters and conditions, essential to their classification and analysis, existed in the records of surgery, without the aid of which I must necessarily have abandoned the enterprise.

I might, however, have given you, like the scientific chemist, the mere results in the last combination and the most concentrated form. My first idea was to do this, shrinking from the possibility of wearying with a detail of the whole of the processes by which they were elaborated, and the tests and materials employed. But when the chemist wishes to introduce any new combination of elements, from which he derives a result differing in some properties from any others previously admitted in the laboratory, he feels it is not sufficient to state the fact that he has obtained a result, but he details the elements employed, the analysis by which he proves them to be those, and no others; the combinations they assumed, and the various tests to which he subjected them, and under what conditions of temperature or external relations, generally, such tests were applied; that all might judge, and not he alone, whether these were capable of bringing new influences to bear, not contemplated by the manipulator, and consequently giving admission to sources of fallacy in the results. Moreover, if the whole process be delicate, complicated, highly susceptible of sources of fallacy, requiring an aggregate mass of material difficult for any single individual to collect, before the result can be fully established, and take its place among the fixed products, it is highly desirable that it should be made public, that it may be elaborated by others elsewhere, with the united aid of many, to produce a mass of evidence sufficiently large to inspire confidence, and indeed a certain conviction of the accuracy of any result obtained, from such an aggregate of material, by competent inquirers.

Influenced by these considerations, I have gone through the whole of the process with the mass in my hands, not so large as I could wish, but collected and sifted with great care. If any one doubt the accuracy of the results, the competency of the processes, or of the amount of the mass subjected to the crucible, and all are open to discussion, I shall hail with great pleasure the efforts of others to attain the same end I have in view. I shall rejoice in those efforts, assured that truth will be obtained, and that fixed principles of practice, in reference to the more important operations of surgery, will supply the place of loose conclusions, based upon erroneous premises; and that the present rules of practice which, whether they may prove right or wrong, are at all events founded upon imperfect analogies; general impressions of imperfectly-recorded and often contradictory experience; and numerical results, either too small in number, or when large, without the necessary guaran-

tees of their completeness and accuracy, to warrant the development of a general principle.

Amputation involves many questions of the highest importance; to decide any one of which certain materials are required to form the elements of judgment; elements not to be acquired by reference to the result of cases of amputation merely. To determine the advantages or expediency of amputation, under various conditions, we must be able to compare its effects with those arising from local disease, and from the forms of injury which usually require amputation, treated under similar conditions; and from those arising from amputation simply, where no pre-existing disease or injury existed, yet performed under a certain similarity of relation and condition. We can only thus, by the knowledge of the separate effects of each, attain the power in complicated conditions and injuries, to anticipate in some instances, and in others to appreciate the combined effects, and to understand their relation to each other, and the causes put in action.

Unvarying precision and entire certainty can rarely, if ever, be attained in medicine, where subtle vital powers form a part of the materials, as it were, on which we are to reason. But in determining and anticipating the progress of disease, how much have we attained, within the last century, that before seemed impossible! How, surely, may we rely upon the truth of certain general rules and bases of prognosis; not always in individual cases, but fully on any large number. As we see in all nature's schemes the perfect similarity of means adopted, under similar circumstances, to produce similar effects, we are warranted in assuming that in the human body, if we can with precision define similarity of circumstance, and of means (in the form of morbid actions which take place), we may also certainly define from these data the end or effect which will result.

In reference to the results of injuries of the extremities and of amputation, the attempt to obtain this power has scarcely hitherto been made; and the present effort, recorded in all its steps in these lectures, imperfect in many of its parts, from the impossibility of the experience of any one individual, how large soever his field of observation, supplying all the wide range of facts required in sufficient number, has at least sufficed, I trust, to convince you that the object in view is fully attainable—that it only requires the *correct and complete records*, during a few years, of some of the chief hospitals, military and civil, in this and other countries, in relation to the cases usually requiring amputation in civil and military life, to furnish the desideratum.

The results, and, so far as possible, results only, which I now propose to recapitulate, and in as simple a form as may be attainable with perspicuity, in treating of a subject branching necessarily into a number of second-

dary, but not the less important parts or subdivisions, may be classified in reference to the purposes for which amputation is employed.

Surgeons resort to amputation with many different objects in view—thus to be defined.

Classification of Objects to be attained by Amputation.

1. To remove a limb, useless from original malformation, or from contractions or deformity induced by disease or injury of remote occurrence, such disease or injury having left no trace in the system or health of the patient. To remove, in other words, a limb which produces inconvenience in a locomotive sense, but is not calculated to give rise to disturbance or deterioration of health, how long soever the limb may be permitted to remain. This forms the smallest class—amputations without the contemporaneous existence of disease or injury to modify the effects of the operation upon the system, and may be called *Amputation for Deformity*.

2. To remove a limb which, from local disease of a part, or the whole of its textures, leaves no rational ground of hope that the limb will ever be restored to health and vigour, or be made useful to the patient, however long permitted to remain; while the continuance of the disease, on the other hand, for an indefinite period, is calculated seriously to disturb the system, deteriorate the health, and ultimately endanger and shorten the life of the patient—*Amputation for Chronic Disease*.

3. To remove a limb at once, when so severely injured as either to be clearly incurable, or so likely, by its effects on the limb and the system, to destroy life before any hope can be entertained of completing the reparative process, that the attempt is not deemed justifiable; thus anticipating any effects depending on the progress of diseased actions in the shattered limb, and their influence on the system, constituting the class of *Primary amputations*.

4. To remove a limb during the first twenty days of treatment, which has been severely injured—not to anticipate the first effects, which have, on the contrary, been allowed to supervene, but to avert the ultimate result of those effects when they threaten to be fatal, or have so far added to the local injury, as to leave no hope of a more favourable period for amputation, or the possibility of cure, if longer-retained. These supervening actions are often of specific and well-defined character, such as secondary hæmorrhage, gangrene, partial disorganisation from excessive suppuration, &c. And inasmuch as the operation is performed in the intermediate period between the non-supervention of febrile action and its subsidence, usually shortly after the full establishment of the suppurative processes, these cases may be denominated *Intermediary amputations*.

5. To remove a limb which, from the effects of an injury while under process of treatment (and after the febrile action first induced has subsided), is shown to be incurable—certain to prove useless, even if union take place; and if longer allowed to remain, to involve the system generally in disease, leading to a fatal result. These constitute *Secondary amputations*, properly understood and defined, and exclusive of the *Intermediary*, defined in the last class.

These five classes of cases, supplying causes for amputation, evidently comprise, each in their outline, many sources of influence upon the *progress and result* of the operation.

In the first class, indeed, we must evidently look for the *effects of the operation* pure and unmixed upon the system, exposed only to such influences as act upon the subject before operation; and upon all not amputated, and treated in the same locality. Here we test the influence of amputation, and test the effects of *different modes of amputation and of site*, whether performed on the upper or the lower extremity.

The second class gives the effects of the operation, in combination with the effects of a local disease, upon the system, in the majority of long continuance.

The third, fourth, and fifth, give the effects of the operation superadded to the previous shock, more or less recent; and in the fourth and fifth, in addition, the effects of local diseased actions. The effects of the operation are thus complicated by the effects of the injury, according to the period elapsing from its infliction.

To anticipate the result of the most complicated combinations, we must be well acquainted with each separate class of effects. Hence the necessity of an inquiry into the effects of chronic and local diseased actions of the extremities upon the system: the same of the injuries of different nature, extent, and degree, and in different sites treated under different conditions of external circumstances. This inquiry concludes the **FIRST PART** of the subject.

The **SECOND PART** leads us to the effects of amputation, *per se*, on a healthy frame, and to the effects of the operation when superadded to a long-continued chronic local disease. These classes of results afford us the means of determining the relation between the effects and results of amputation, in those cases where amputation is performed for injuries, at three different periods from the receipt of the wound, and when the two (effects of injury and of amputation) are consequently in combination. The results of each singly may be compared with the results of both combined. This forms the true subject of the *second part*. The first part you will find comprised in the first ten lectures: the second in the remaining nine.

Effects of Chronic and Local Diseased Actions of the Extremities upon the System.

The diseased actions usually leading to amputation, are those only which interest us especially; but these are various. Diseased joints, the majority scrofulous, form by far the largest proportion. Caries, necrosis, tumours, gangrene, ulcers, are the chief forms in the remainder.

Dr. Hayward gives an account of all the diseases for which amputation was performed subsequent to the opening of the Massachusetts Hospital. These amputations amounted to 47 on 45 patients.

	Died.
20 for diseases of joints.....	3
15 ulcers	1
4 frost-bite.....	0
3 abscess and fungus.....	1
2 fungus hæmatodes	0
2 tumours	1
1 deformity	0
—	—
47	6

Mortality 1 in 7.8.

Only 5 of this number were of the upper extremity; and 2 of these were diseased joints.

In Dr. Lawrie's record of amputations for disease in the Glasgow Infirmary, the numbers amounted to 153; and 98 were performed for diseased joints; 26 for caries and ulcers; necrosis and tumours, 12 each; gangrene, 5. 1 in 5 of the diseased joints amputated were of the upper extremity, although still more than half of the whole number were of the *knee*.

Dr. Norris reports from the Pennsylvania Hospital, that in 23, the total cases amputated for disease in a given period, only 5 were of the upper extremity. The mortality in the lower extremity, 1 in 4.5; in 5 of the upper, none.

Of the final results of any number of these cases of local disease *treated without amputation*, the *proportionate mortality*, or the *causes of death*, there is no statistical record, so far as I know, to enable us to draw any very positive conclusions. Speaking from general experience, however, I have little hesitation in saying, that the more usual terminations of diseased joints, ulcers, caries, and necrosis, is hectic fever, occasionally accompanied by disease of the viscera, of the lungs more especially, and the mucous membranes of the intestines. Gangrene, malignant tumours, and fungus hæmatodes terminate somewhat differently: if spontaneous gangrene, the fever developed is very generally typhoid, the patient passing rapidly from delirium to a state of coma. With malignant diseases and tumours, the same form of morbid action is frequently developed in some distant part, often involving, directly or indirectly, some important viscus: at other times, the patient sinks, with hectic or irritative fever,

worn out at last with the incessant drain and irritation kept up, exhausting all the powers of life.

As the cases for which amputation is recommended are always deemed incurable, we may consider that all, sooner or later, lead to death by these diseased actions, if life be not cut short by the more sudden appearance of some fatal and irregular action.

Thus much for the effects on the system of the local diseases for which amputation is usually performed. We may safely conclude that the diseased actions do not kill rapidly; patients linger for years, living for half a lifetime with ulcers, tumours, and even diseased joints and caries; yet all that are incurable ultimately hasten, and not only indirectly, but often in a direct manner, the death of the patient.

Effects upon the System of Complicated Injuries of the Extremities occurring in Civil and Military Life.

Leaving the class of chronic diseases of the extremities, and their effects upon the system where any actions set up are in the majority of cases characterised by little intensity, and kill rather by the gradual exhaustion of the system from long-continued waste and irritation, than by the development of sudden and fatal supervening diseases during treatment. What did we find the effects of severe injuries of the extremities fracturing the bones, crushing and lacerating the soft parts, to be, when they are treated without the intervention of amputation? What is the proportionate mortality, and what the causes of death?

Cases of injury in their progress present a vivid contrast to the cases of chronic disease. As the morbid state in injuries is sudden in its supervention and violent in its characters, so are the diseased effects resulting neither mitigated in form nor slow to destroy: that an injury to the extremities is more dangerous than a chronic disease, becomes the first and inevitable inference. Whatever dangers amputation may bring, we are thus informed, therefore, that *they are superadded to a class of cases often rapidly fatal without its aid or intervention*. In diseases requiring amputation, the site or nature of those actions is of comparatively little importance—not so in injuries. Many circumstances and conditions require consideration in determining the effects upon the system of injuries, which exercise but an obscure or trifling influence on the progress and results of cases of disease.

Different classes of injuries give different results. There is a difference to be observed even between the injuries of civil and of military life, where fracture of bone and laceration of soft parts may alike be the chief features of the case. Our statistics on the result of injuries in civil hospitals are very imperfect; the two American hospitals to which I have alluded, and the Glasgow Infirmary, alone afford any

collected data to which I can refer, and these are far from being as complete as could be desired.

In reference to the results of treatment without amputation adopted for injuries of civil life, I am only able to refer you to Dr. Lawrie's paper singly among the records of surgery, for a few data in a collected form.

In 40 compound fractures and dislocations treated and not amputated, 17 died; giving a mortality of 1 in 2.3 in the lower extremity, and of 1 in 2.2 in the upper. The diseased actions supervening and causing death is not stated.

It is remarkable that in this series the upper extremity gives a mortality even greater than the lower.

In reference to the injuries of military life, chiefly gunshot, the largest number recorded showing the *mortality* of injuries of military life (where one or more bones of the extremities are broken with laceration of soft parts), we owe to the conviction of the fatal results of amputation entertained by the surgeon-general of the Prussian army in 1762, M. Bilguer. In 816 gunshot fractures of the extremities received into the hospital under his direction at one time, in no single instance was amputation permitted.

Of this series (in round numbers) *one-half* died; *one-fourth* lived, retaining crippled and useless limbs: *one-fourth* alone were returned cured, able to do duty in person, or to work at any trade.

Of the diseased actions causing death, nothing is said. This deficiency, however, in the preceding lectures, I have supplied by the results of another series of cases treated in hospitals under my own direction.

In reference to the mortality and disability resulting in this series consisting of 235 cases, including 55 partial fractures of the bones of the extremities, you have seen that 82 were amputated.

38 of which were followed by death.

38 of the remainder died under treatment.

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76

The mortality was 1 in 3—one-third.

And more than half of these cases of death without amputation were induced by vital actions, disturbed, impaired, and finally arrested *without organic disease or lesion of structure*; the remainder with affections of viscera, often purulent depôts, and various accidental or irregular actions, such as secondary hæmorrhage, gangrene of limb, &c.

115 recovered with useful limbs—say *one-half*.

44, or somewhat more than *one-fifth*, recovered, but crippled by the removal of a limb.

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159

Thus the united *favourable result*, as regards the question of *life*, is the recovery of 1 in

1.48, or two-thirds of the whole number, including the results of amputation.

The united *unfavourable* result, considering the loss of life or of limb as both unfavourable, the latter closely corresponding with M. Bilguer's *invalids*, will be 120 cases in 235, or 1 in 1.9—say *one-half*.

If *partial* fractures, however, be excluded, and those injuries which only secondarily involve the integrity of the articulations (both less fatal classes of injuries), and in the 235 amounting to 55, we find 1 in 1.5 was the *combined unfavourable result* of the gravest character of injuries, or two thirds; 1 in 2.4 losing their lives between one-half and one-third, and 1 in 4.2 their limbs only; a fourth, therefore, crippled. Still the mortality is considerably less than one-half; and the fourth crippled are free from the permanently diseased state of a shattered limb, which remains not only useless in a locomotive sense, but hurtful to the patient's health.

Thus, in reference to Bilguer's experiment, the worst result where amputation was performed in a large proportion of the worst cases, and many performed under most unfavourable circumstances, is a *considerable saving of life*; and no greater proportion of "maimed" results, all are in a *better* state by the removal of the limbs, than if they had been allowed to retain them, and survived; while one-third instead of one-fourth are returned cured to their occupations. I have taken here, I believe, as unfavourable a series as well could be selected to compare with Bilguer's series; the result, therefore, is the more conclusive and striking. If the 34 cases of death under treatment had been amputated at an early period, at a very low average, more than one-half would have been saved, thus adding from 18 to 20 to the 42 saved with loss of limb, reducing the actual loss of life from 73 to 53, or 1 in 3.4, between *one-third* and *one-fourth*; the maimed without disease to 62, or 1 in 2.7, between *one-half* and *one-third*. The cured retaining useful limbs remaining as before, *one-third*.

If the cases treated in one of the hospitals under my charge during a period of thirteen months (the series comprising complete fractures with lacerated wounds, and nearly one-third of which were injuries involving large articulations), to the exclusion of partial fractures and cases where the joints were only secondarily involved, be analysed (see Tables I. and II.), it will be found that 100 cases remained and were treated to the end after the whole series of 180 had been weeded, as it were, by 43 primary amputations, and 37 (generally of the worst cases) had also been eliminated from the 137 at first submitted to treatment by secondary, or at least subsequent amputations, 34 still died of the 100, giving a mortality of 1 in 3.

This seems to be as favourable a view, therefore, as can be taken of the result of these injuries when treated; and if amputa-

tion be not resorted to, rarely less than half will perish, and while from a *third* to a *fourth* may be cured and retain useful limbs, the remainder with *useless and crippled limbs* and shattered health will be left to drag on a very painful residue of life; the maimed limb, unlike a healthy stump, proving a pregnant source of future disease and discomfort.

In conclusion, then, it seems by such evidence as can be obtained, that the mortality of complicated injuries of the extremities, whether in civil or military life, if treated, is rarely likely to be less than one-half, when upper and lower extremities are in about equal proportion, and not more than one-third are joint cases. In addition to this, a considerable number preserve only shattered and useless limbs; the loss of useful limb and of life taken together, cannot be estimated at less than two-thirds of the whole number treated. If the average were applied to the upper extremity alone, the deaths would probably be 1 in 7 or 8 only; but if to the lower, as much as 1 in 1.7; and thus varying, according to the modifying conditions already applied, to the series of 100 cases.

The result of not amputating is to alter the proportion of dead to the crippled, increasing the former, and by the same number diminishing the latter; in addition to which the maimed are left more or less suffering for life by the limb retained, in addition to the total loss of the use of the limb.

Are we to conclude from these large results that it is always expedient to amputate, and that an advantage as clear and evident will always result over the practice of treating such injuries? May we venture to state the positive advantage gained, under all circumstances, to be as stated above?

The preceding lectures must have amply proved how full of sources of fallacy are such broadly-stated statistical results, and how vain is any reliance on their undeviating accuracy. These results, you are already aware, therefore, are *true only as regards certain conditions and proportions*. Change any one of these, and the results are changed! To arrive at a close approximation to truth, and to correct averages applicable to any series of cases, we must know, and be in a position to determine, what is the mortality and what the diseased actions causing death in cases of fracture under various conditions and proportions to each other and the whole; and be enabled to compare these analysed or isolated results with the mortality and diseased actions supervening in amputations under similar circumstances, before we can solve any of the questions connected with the operation, its comparative mortality and expediency.

Several lectures were devoted to demonstrate to you how infinitely any general average of mortality varies, and what the different rates were, according,—

First. To the *site of injury*, whether involving upper or lower extremity.
Secondly. To the *nature of the injury*, its *degree and extent*.
Thirdly. To the nature of the *external circumstances* prevailing during the treatment of the case.
Reference to the analysis already given of this 100 cases, will show that the average, if all the cases were under any one of the conditions just stated, would be completely changed. Thus it is the correct average on 100 cases, and probably would not vary much in any other 100 where similar proportions exist of injuries of upper and lower ex-

tremity; of joint cases, and of fractures merely; of favourable or unfavourable cases for treatment, and treated under similar circumstances. Until surgeons will thus classify their cases, no correct average can be stated: that which is correct of one combination of these leading distinctions, is utterly incorrect if applied to another, and a different classification.
A glance at this summary of results, classed after strict analysis in reference to the predominance of these three leading circumstances or conditions, show, in the most obvious manner, the idleness of any attempt to establish averages except in relation to them.

			UPPER EXTREMITY.			LOWER EXTREMITY.		
No. of Cases,	Deaths.	Mortality.	No. of Cases.	Deaths.	Proportion.	No. of Cases.	Deaths.	Proportion.
30 injuries to joints with fracture.....	18	1 in 1.6	13	3	1 in 4.3	17	15	1 in 1.1
70 compound fractures not involving joints....	16	— 4.3	39	4	— 9.7	31	12	— 2.5
100	34	1 in 2.9	52	7	— 7.4	48	27	— 1.7

These few figures express and embody very important results. The mortality in 100 cases of complicated injuries of the extremities, according to the usual mode of stating it, is 1 in 2.9, or say *one-third* of the whole number treated. You cannot doubt after this evidence that such an average, although strictly correct as regards the series in question, is yet entirely subject to a variety of conditions and proportions; and that if these are altered, the average on the mass is totally inapplicable and incorrect.
This fact has been enforced and demonstrated in several lectures; let us take a review of some of the chief results and their bearing upon this part of our subject.
If the cases treated were all wounds involving joints of the same relative number of upper and lower extremity, and treated under the same circumstances, the proportionate mortality would be..... 1 in 1.4
If all were fractures in the same manner with the single difference of not involving joints..... 1 in 4.4
Instead of *two-thirds*, less than *one-fourth* perish. Again :—
If all the injuries were of the upper extremity, similar in their degree and other circumstances (one-

third being of joints), the mortality would be 1 in 7.7
If all of the lower extremity (one-half joint cases) 1 in 1.7
If, on the other hand, all were injuries of joints in the upper extremity 1 in 4.3
If all were fractures without injury to joints 1 in 9.7
If all were of the lower extremity and injuries of joints 1 in 1.1
If all were fractures without injury to joints 1 in 2.4
Nothing can be more palpable, striking, or obvious, than the modifications in the results induced by site, and this one distinction in the nature of wounds, viz., whether implicating an articulation or not.
But it has also been demonstrated to you, that if a series of cases were treated under favourable circumstances or under unfavourable circumstances, or a series of favourable cases for treatment, and a series of doubtful and again of unfavourable cases were submitted to treatment, every one of these conditions would produce a no less striking difference in the average number of deaths. A summary of the results brought forward in preceding lectures and in detail, in reference to these conditions, can leave no room for doubt.

	Site.	No. of Cases.	Deaths.	Mortality.	Total Mortality.
INJURIES INVOLVING JOINTS, doubtful or unfavourable cases for treatment— <i>external circumstances favourable</i>	Upper ex- tremity	6	1.	1 in 6.	2.2
	Lower ditto	5	4	— 1.2	
COMPOUND FRACTURES NOT INVOLVING JOINTS—similar injuries to the above, with this distinction only, and treated under similar circumstances	Upper ex- tremity	2	2*	— 1.	3.0
	Lower ditto	4	0	0 in 4	
JOINT CASES—similar character, but treated under <i>unfavourable circumstances</i>	Upper ex- tremity	7	2	— 3.5	1.4
	Lower ditto	12	11	— 1.0	
Fractures—ditto	Upper ex- tremity	6	2	— 3.0	1.5
	Lower ditto	12	10	— 1.2	
COMPOUND FRACTURES — favourable cases † treated under <i>favourable circumstances</i>	Upper ex- tremity	16	0	0 in 16	0 in 18
	Lower ditto	2	—	0 in 2	
Similar class of cases treated under <i>unfavourable circumstances</i>	Upper ex- tremity	17	0	0 in 17	14.
	Lower ditto	11	2	1 in 5.5	
		100	34	Up. extremity 1 in 7.7 Lower ditto 1 in 1.7	1 in 2.9

This summary shows at a glance that these important conditions, viz., the nature of the wound, the site, and the external circumstances under which the cases are treated, exercise a decided influence; it also furnishes the means of determining the proportionate amount of influence of each of these conditions upon the mortality. We are warranted, therefore, in the following conclusions:—

In reference to the Influence exercised by the Nature of the Injury and the External Circumstances.

First. Injuries directly implicating any of

* Both with complicating wounds of chest.

† Under the denomination of *favourable cases for treatment*, none of the compound fractures of the femur are included, such cases never being favourable; and so of lacerated wounds into joints with fracture of bones. The *favourable cases*, therefore, are exclusive of fractures involving joints, and of compound fractures of FEMUR, the two most fatal classes of injury.

the large articulations, from the ankle and

wrist upwards, are all more or less doubtful, and often decidedly unfavourable, cases for treatment: lacerated wounds into joints attended with partial or complete fractures, can only be compared with fractures of the worst kind; and even thus classed, and when both are treated under similarly *favourable* circumstances, the mortality in the former class is largely increased, especially in the lower extremity, when the deaths in cases of joint injuries is nearly quadruple that occurring from fractures simply. In the upper extremity the present series does not afford any fair criterion; but I have always found in doubtful cases that the mere fact of an articulating surface being implicated was sufficient to turn the balance unfavourably.

Secondly. This difference between the results of fractures implicating, and the more grave cases of fractures not implicating joints, so palpable and evident when both are treated under *favourable* circumstances, is almost lost when both classes are treated under *unfavourable* circumstances. Notwithstanding the mortality in the class of injuries to

joints is increased nearly one-half in the upper extremity, and in a lesser degree in the lower, yet the mortality in bad cases of fracture is increased in a so much larger proportion, that the difference between the results of the two classes of cases in the aggregate is only a minute fraction, the mortality being as 1 in 1.4 to 1 in 1.5. The proportions in the upper and lower extremity maintain about the same relative rate in both classes; injuries of joints in lower extremity being slightly more fatal.

In cases of injury of joints the upper

extremity gives a mortality of .. 1 in 3.5

In the lower extremity 1 in 1.0

In fractures not implicating an articulation, upper extremity 1 in 3.

In ditto, lower extremity .. 1 in 1.2

Thirdly. In reference to favourable cases of fracture for treatment, large numbers, it is here shown, are required to determine the relative influence of external circumstances upon the mortality, since it is rarely heavy. The series brought forward only shows that the mortality in the upper extremity is not 1 in 16; in the lower, not 1 in 2, when treated under favourable circumstances. In the upper extremity it is not 1 in 17, and only 1 in 5.5 in the lower, when the circumstances are unfavourable.

Fourthly. Hence the ultimate conclusion at which we arrive is that, in reference to the mortality, the influence of external circumstances is greatest upon favourable and doubtful cases for treatment, and of site upon doubtful cases. Neither site nor external circumstances, nor any distinction in the nature of the injuries, when these are sufficiently grave to constitute a class of cases unfavourable for treatment, exercise any important influence on the mortality, inasmuch as all prove fatal.

An incurable injury of the forearm, if treated to the end without amputation, is likely to prove as fatal a case as any similar injury in the lower extremity. A badly plastered, useless, and painful limb, is the nearest approach to a successful result that can possibly follow; the great majority of patients will die under treatment.

These are the last results of the facts, and they inculcate the following

PRINCIPLE OF PRACTICE.

In favourable cases for treatment, the attempt to conduct them to a cure with the view of saving a useful limb, is always to be attempted wherever the injury be situate, whatever its description, or the nature of the external circumstances. In doubtful cases the nature of the external circumstances, and the *site* of the injury, when chances of cure and danger of failure are equal, as regards the *nature* and *extent* of the injury, decide the question: if situated above the knee, and the external circumstances are unfavourable, the balance is by those two conditions turned

against the patient; and if treatment be undertaken, it should be with this knowledge, and not at the recommendation of the surgeon, as calculated to save a useful limb. In cases unfavourable for treatment, wherever the injury be situate, and whatever be the condition of external circumstances, only one of two results are to be expected—the death of the patient, or the loss of the limb by subsequent disease or by amputation. The broken-down invalids who occasionally escape death, still retain a useless limb.

I have hitherto been speaking of the results of injury as regarded mortality alone, and in cases where amputation is not allowed to intervene in any stage, and the influence which the three principal conditions exercise upon it, and not upon the *nature of the diseased actions* supervening and proving the immediate *cause* of death; still less have I yet brought before you the conclusions arrived at in reference to the varying proportions of cases under the influence of such conditions requiring amputation, when the surgeon is willing to resort to it during the progress of treatment, and of those which allow no opportunity, and therefore perish.

This, however, is necessary, in order that the dangers attendant on treatment, and on amputations performed at three different periods in similar injuries and under similar circumstances, may be ultimately brought out and contrasted, and the principles of practice, in reference to the more complicated cases of injuries to the extremities, determined.

Nature of the Diseased Actions causing Death.

In reference to the diseased actions causing death in cases treated and not amputated, and the influence which the three conditions specified as affecting, in a remarkable degree, the mortality, may have upon the character of these actions, a very different result is obtained.

The *character* or *nature* of the supervening fatal actions are not materially affected by the degree or nature of the injury, its site, or the external circumstances under which the cases are treated, if we except that injuries of joints do not seem equally prone to induce secondary inflammations and purulent depôts in vital organs or distant parts.

The causes of death may, therefore, be taken on the whole series of 34 fatal cases of complete fracture, and 4 of partial fracture. Fever was the predominant diseased action in 21; 18 of defined character, viz., 10 hectic, 5 remittent; continued, intermittent, and irritative, 1 each; 5 were attended with secondary diseases of viscera, which probably, from the symptoms, existed in 4 more. In 2 of the 21, also, the limbs were gangrenous.

Seventeen deaths occurred by what I have termed "*accidental and irregular diseased actions*," such as shock, tetanus, hæmorrhage, complicating wounds in other parts; 5 of this

number presenting, in addition, secondary inflammations of lungs or liver; 3 died in which the causes were unascertained.

The conclusion from these data, examined in great detail, let me recall to your memory—it was this. The mortality was caused in more than half the fatal cases, by actions leaving no trace of structural change or physical lesion, by deleterious impressions made upon the nervous centres, disordering the circulation, and deranging the vital functions. In the remainder of the fatal cases, the same influences were sufficiently manifest, although in a less striking manner, since they were accompanied with lesions of structure, local and organic, chiefly secondary diseases involving distant parts, and often important organs, in suppurative and inflammatory actions, sufficient to account for the death of the patient.

In any series of cases, submitted to treatment in the first instance, (but amputations performed during the progress of the case, whenever the supervening diseased actions, local or general, indicate the hopelessness of any further attempt to save a limb, the condi-

tion of the patient still allowing such an alternative,) the proportion of amputations required; and of the cases which terminate fatally among those remaining under treatment, it will be found, is not less strikingly changed, according as the cases fall under one or other of the leading conditions, the influence of which has been already shown, in reference to the mortality of cases submitted, from the beginning to the end, to palliative or curative treatment.

The proportion of deaths to amputations caused by the supervening actions in 137 (the number comprised in the series of *complete* fractures, and exclusive of partial fractures and of injuries to joints, only secondarily and indirectly implicated), is as 1 in 3.7 to 1 in 4. The latter being the proportion of deaths in all the cases not amputated.

A source of fallacy exists in the average thus taken, however, not only because it varies in the two classes of injuries, but in the injuries of the upper and lower extremities, which are not in equal proportions; the results, therefore, require to be stated in the following manner:—

		Proportion.	No. of Amputations.	Proportion.	Deaths—not Amputated.	Proportion.	Proportion of combined unfavourable Results of Treatment.			
Class.	No.									
FRACTURES.....	93	Upper extremity.....	50	1.8	11	4.5	4	1 in 12.5	15	1 in 3.3
		Lower extremity.....	43	2.2	12	3.5	12	— 3.5	24	1 in 1.7
			93		23	4.0	16	— 4.3	39	1 in 2.3
FRACTURES WITH PRIMARY INJURIES TO JOINTS	44	Upper extremity.....	16	2.7	3	5.3	3	1 in 5.3	6	1 in 2.6
		Lower extremity.....	28	1.5	11	2.5	15	— 1.8	26	1 in 1.0
			44		14	3.1	18	— 2.4	32	1 in 1.3
137			137		37	3.7	34	1 in 4.0	71	1 in 1.9

It will be perceived that the proportion of amputations in fractures, when of the upper extremity, is three times that of deaths; while in the lower extremity, the proportion of deaths and amputations are equal: but the upper compared with the lower, shows the amputations in the former are only 1 in 4.5, instead of 1 in 3.5; while the deaths in the upper are only 1 in 12.5 as compared with 1 in 3.5. The combined unfavourable results accruing from the treatment of fractures is just *doubled* in the lower extremity, the *amputations being somewhat fewer, but the deaths nearly quadrupled*.

The cases of injuries of joints, compared with each other and with the preceding class, show the combined unfavourable results in both upper and lower extremities to be considerably larger: this difference being in equal proportions, however, on both upper and lower, and caused principally by the

excess of deaths, compared to amputations. Fewer amputations are performed in the upper extremity for joint injuries than for fractures, but the proportion of deaths is more than doubled. Nearly one-third more amputations, on the contrary, are performed in joint cases when of the lower extremity, and the proportion of deaths is only just doubled.

The variation or difference in the proportion of amputations in each of the two *classes* of injury is from one-third to one-fourth; the former being the proportion in fractures implicating joints.

The relative proportions between those required by the upper and lower extremity in each varies. In injuries of joints, a greater proportionate number is required in the lower extremity compared with the upper, than in the class of fractures only.

The variation in the proportion of deaths in

each of the two classes is greater than the aggregate difference in the amputations. The proportion in joint injuries being between one-half and one-third, that in fractures *one-fourth*: in the former, however, the cases present nearly double the proportion of lower extremities. Still the mortality, which is *more* than doubled in joint injuries of the upper extremity, is increased just double in the lower. The difference is not, therefore, very sensible; but the deaths decrease in proportion as the amputations increase.

These proportions you are prepared to find again vary with the favourable and unfavourable nature of the injury, and the external circumstances under which treated.

In reference to the external circumstances, amputations are in larger proportion under favourable circumstances, and *vice versa*; and as the *amputations decrease*, the *mortality* in the cases treated *augments*. Thus, under different circumstances, amputation and death change their relative proportions; the one occupying, as it were, the other's place. But while unfavourable circumstances only diminish the number of *amputations* as much as *one-half*, the *deaths* become nearly *quadrupled* in the remainder of the series treated.

You have already had before you the altered proportions of amputations under the combined conditions of favourable nature of injury and of circumstances. Let me repeat it.

Fractures not involving Joints.

	Proportion of Amputa- tions.	Proportion of Deaths.
In favourable cases treated under favourable circumstances	1 in 4	in 18 0
Ditto under unfavourable circumstances	1 in 1.7	1 in 16.
Doubtful cases under favourable circumstances	1 in 1.4	in 4 0
Ditto unfavourable	1 in 2.	1 in 3.
Unfavourable cases under favourable circumstances	1 in 2.8	1 in 1.0
Ditto unfavourable circumstances	1 in 6.2	1 in 1.

Thus amputations are most numerous in doubtful cases treated under favourable circumstances; next in favourable cases treated under unfavourable circumstances; thirdly, in doubtful cases under unfavourable circumstances. Although one-fourth of the favourable cases treated under favourable circumstances seems a very large proportion, it will cease to appear so when it is recollected that no primary amputations were performed in this class, and no death occurred among those not amputated; thus one-fourth expresses the combined unfavourable result.

The deaths are most numerous in proportion to the number of amputations in unfavourable cases; whatever the nature of the

circumstances, all the cases were fatal. Doubtful cases, under unfavourable circumstances, stand next in proportion: lastly, favourable cases under unfavourable circumstances. In the class of doubtful and favourable cases remaining for treatment under favourable circumstances, there were no deaths. On these facts were founded the three conclusions:—

1. That when circumstances are favourable for treatment, and the cases, from their nature, offer a fair chance of recovery, although a fourth may require amputation by the development of morbid actions, few or none will die under the treatment adopted, with a view to save the limb. Even in doubtful cases, although a large proportion, say one-half, may require amputation, yet few or none will die under the previous treatment if carefully watched, and amputation be not deferred too long. But in the treatment of unfavourable cases under the best circumstances, not a third will allow of amputation after the first period has passed, and all not amputated will perish. A portion of those operated upon who recover will be nearly the only ones saved.

2. When the circumstances under which the treatment must be conducted are unfavourable, the number of amputations in doubtful and unfavourable cases for which there is opportunity, with a fair chance of success, is much diminished; and the number of deaths is increased in proportion. In favourable cases the number of amputations is, on the contrary, largely increased, and the deaths in a lesser degree. The opportunities for amputation are most rare in unfavourable cases under unfavourable circumstances. On the deaths which take place in all not amputated in this class, external circumstances have no control, at least in so far as the *result* is concerned, although they possibly, in some degree, modify and control the character and duration of the supervening diseased actions.

3. From these general facts the last conclusion may be drawn, viz., that in favourable and even in doubtful cases, judicious treatment, if it will not always save the limb, at least need not cost the patient his life (unless in exceptional cases), if good judgment be exercised in stopping the curative treatment, and resorting to amputation at the proper period. Thus, in doubtful cases, much may be adventured, in the first instance, to save a useful limb. In unfavourable cases, on the contrary, amputation or death, sooner or later, are the only results that can be anticipated; and the only object and legitimate end of any treatment is to save the patient's life, until a proper or favourable period may be selected for operation.

The Nature of Diseased Actions causing Amputation.

A comparison of the causes producing

death during treatment, and the supervening diseased actions necessitating amputation in order to save life, show the difference to consist chiefly in the large predominance of fever, of distinct types, among the causes of death. In thirty-eight, nearly one-half died with fever of defined type. In the amputations, although febrile action in many was present, no fever of a very defined character was fairly established, except hectic, in some of the secondary operations.

Again, some causes produce death which do not appear among the causes leading to amputation; such, for instance, as shock, complicating wounds, secondary inflammations, purulent depôts, &c.

Some actions there are which necessitate or lead to amputation, but are never causes of death; as, for instance, contracted and useless limbs, paralysis from local injury, pain and nervous irritation from lodgment of a foreign body, &c.

If we compare causes of amputation in joint injuries, and in cases of compound fracture, without such complication, the cases of secondary hæmorrhage and tetanus necessitating amputation occur exclusively in *fractures* and not in *joint cases*.

In the causes of death between these two classes of injury, we have seen that there are distinctions equally obvious; in fractures not involving joints only one-third of the deaths were from "irregular" and accidental complications, and two-thirds febrile: in joint injuries, on the contrary, more than one-half the deaths were caused by the class of "irregular" actions, the rest febrile.

In reference to periods of amputation, whether in the intermediate or secondary period, certain differences may be observed. Tetanus in the series before us was never developed in the secondary period, although thrice in the intermediary. Gangrene preponderates in the secondary period. Those causes of specific character which may be classed among the irregular or accidental, are presented as causes of amputation in the secondary more frequently than in the intermediary period; in the latter they amount to one-third, in the former to more than one-half. We shall shortly see that a still stronger difference exists between the causes of *death* in the amputations performed at these two periods.

It only remains to be shown how these diseased actions, supervening on fractures, treated and leading to amputation or to death, vary according to the favourable or unfavourable nature of the injuries for treatment, and of the external circumstances.

In favourable cases the majority of amputations are performed in consequence of the supervision of certain well-defined and specific causes, such as may with propriety be classed among the irregular and accidental causes: secondary hæmorrhage, sloughing, contraction of limb, periosteal disease, &c.

In doubtful cases a large proportion of the amputations have a similar cause; not far from one-half, however, are amputated for general and local deterioration, marked by no very distinctive characters, but clearly indicating the hopelessness of further efforts to save the limb, and this is the chief difference observable.

In unfavourable cases seven-eighths are amputated from the hopelessness of conferring benefit by treatment, and not from any specific or peculiar action, sloughing and secondary hæmorrhage appear alone as specific causes.

From these facts I pointed out, as a legitimate inference, that when *favourable* cases are selected for treatment, only such of them will require amputation as may become the subject of some accidental complicating diseased actions; but in *doubtful* cases nearly one-half may be expected to require operation, as the natural result of the inflammatory and suppurative processes usually set up. When *unfavourable* cases, by adverse circumstances, or error of judgment, are submitted to treatment, seven-eighths of the whole, if so many afforded opportunity, would require amputation from the evident hopelessness of cure, and the consequent and natural progress of all the actions, local and general, from bad to worse, and all with rare exceptions not amputated, die. There are fewer specific causes of amputation in this class than in any other. In a series of 23, only three cases occur—secondary hæmorrhage and sloughing being the diseased actions.

Comparing these causes of amputation with the causes of death in each of these classes, we find that in the *series of fractures* (exclusive of joint injuries) 55 favourable cases only gave rise to two deaths: one with bilio-remittent fever and secondary abscesses of lungs and liver; the second with febrile action, type not ascertained.

One patient died in 24 doubtful cases during treatment, from effusion in the chest and vomica in the lungs.

Thirteen unfavourable cases were treated to the end, and all died—5 by hectic, with attendant bad actions; 1 bilio-remittent; 2 type uncertain; 1 secondary hæmorrhage and ensuing gangrene; 2 by shock; 1 complicating wounds and purulent depôt; 1 cause unknown at the end of three years.

As to the influence of external circumstances upon the diseased actions causing amputations, as in reference to deaths, we find the elements are the same in all—some difference existing in the proportion of one kind of diseased action to another. Mortification and sloughing—low action or excessive local disease predominate in cases treated under unfavourable circumstances, and indicate the kind of influence chiefly exercised on the nature of the supervening actions. The comparative frequency of the necessity for amputation, and the proportionate mor-

tality in cases not amputated, constitute the most important of the effects.

When the causes of death were compared with the causes of amputation, *both in reference to the site of injury*, as regards the upper and lower extremity, we found that more than one-third of the amputations of the lower extremity are performed to anticipate the full development of actions, the fatal consequences of which could not be doubted. In one instance only was this done in the forearm and hand, indicating that much more may be adventured in injuries of the latter during the first periods. Secondary hæmorrhage, however, preponderates in the forearm, wrist, and hand, as three to one. Sloughing and gangrenous action appear in both, but mortification of the extremity of the member in the lower extremity only. A sloughing action was developed in three of the upper extremity. Specific causes preponderate in fracture not involving joints, more than in injuries of joints, both in the upper and lower extremity. If we turn to the *causes of death*, considered in reference to the *site*, although we have only seven of the upper extremity, yet these present examples of many of the principal forms of disease which carry off those whose injuries are in the lower, viz., *shock, hectic, and exhaustion, with complicated wounds and sloughs, bilio-remittent fever, and purulent depôts*. These few cases, however, do not give, as do the lower extremity, any cases of trismus, secondary hæmorrhage, delirium tremens, and gangrene of limb.

Larger numbers, especially of the upper extremity, are required, before we can safely determine that cases of the upper are really more exempt from these grave diseased actions than are those of the lower extremity.

We have thus determined, first, the predominating actions developed by chronic and local disease of limb; and secondly, by those supervening on the injuries of civil and military life, through almost every phase of condition and circumstance. These actions constitute the effects of such injuries, and lead when grave to one of two disastrous results—amputation or death, in proportions which we have again seen alternate with each other, according to the nature of the injury and the external circumstances under which the cases are treated.

With these conclusions, determining the effects of those local diseases and injuries of the extremities, which form the classes requiring amputation, we are prepared to understand and appreciate the effects of the operation singly, and when superadded to these states; and, finally, to determine by comparison, the advantages and disadvantages of amputation when adopted in such cases. This forms the proper subject of the SECOND PART of the summary, the details of which are comprised in the last nine lectures of the series.

COURSE OF LECTURES ON THE ANATOMY, PHYSIOLOGY, AND DISEASES OF THE EAR.

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Arranged and Prepared from Notes
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LECTURE IX.

Organ of Hearing in Mammalia.

IN this class of animals the auditory organ in internal construction will be found to assimilate closely to that of man. Viewing the external appendages, however, there are no orders of animals in which greater variety of figure and size is presented to the observer of nature, than in the accessory parts of the ears of quadrupeds. Nor can the observation be here withheld, that however endless the diversities of conformation which the organ may offer, there are no instances which do not abound in practical correspondence and relation between the means employed and the ends to be attained. To survey in detail the whole range of this great class, were to involve ourselves in a lengthy disquisition upon the habits and organisation of animals, with reference to the faculty of hearing; which more appropriately belongs to the subject of comparative physiology.

The external ear, of which the *auricle* forms the most interesting division, occurs under an extensive range of modifications; for in some orders the auricle will be found altogether absent or present in a very rudimentary and imperfect form; and in others it will be seen to have acquired a very large size. It will be sufficient for our purpose to notice cursorily only the leading distinctions of the several genera comprehended under this class. Instances of the imperfect development of the auricle are abundantly found in the aquatic carnivora. The cetaceous families, including the whales, seal, walrus, mole rat, and zemni rat, possess only obscurely-formed auricles; illustrations of the opposite extreme are afforded in profusion. The inordinate proportions which the external ear attains in the rodentia, canidæ, and ruminants, form a prominent contrast with the condition of this part in the former group. The dog and rabbit tribes are examples of the influence of domestication upon the size and character of the external ear. But it is somewhat remarkable that writers upon the changes of growth and other modifying agencies of