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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—(Continued).

PART II.

EFFECTS OF AMPUTATION *performed on a limb free from disease and a person in health. Effects of amputation performed upon a patient long suffering from chronic local disease. Effects of amputation superadded to the shock of a violent injury, causing fracture of bone and laceration of soft parts. How modified by nature of injury, especially by the different characters of those occurring from the accidents of civil life and from the casualties of the field. Effects of amputation for the injuries of civil life. Effects of the operation for gunshot injuries, in reference to the primary, intermediary, and secondary periods: to the external circumstances: dynamic influences: upper or lower extremity, mode of operation, &c. Predominant diseased actions, causing death in each of the three periods, compared with those producing the same result when similar injuries are treated without operation. Conclusions. Influence of modes of dressing and after-treatment upon the results of amputation.*

BEFORE we can appreciate the effects of amputation when superadded to local disease, or to injuries involving the extremities, we must first be able to determine what are the effects of amputation simply, uncomplicated by any previously-existing disease or effects of injury.

Pure Effects of Amputation.

These effects are local and general. *Locally*—Some inflammation and swelling of stump, with a tendency to superficial sloughing in the cellular tissue, where the knife had divided; partial or imperfect adhesive action between the divided surfaces, and partial or more general suppurative action in the stump, occasionally in parts contiguous. *General*—Some febrile action, marked chiefly by acceleration of pulse, ending a day or two after a suppurative process is established in stump, generally extending from the fifth to the ninth day. By the tenth day, total cessation of all inflammatory or febrile action. Subsequently, a depôt of matter occasionally forms about the stump, or above it, requiring an exit to be made, but not obviously affecting the system. These effects vary in degree: in one case a marked tendency to diarrhœa quickly supervened, betokening, probably, the influence of shock and the nervous system upon the mucous surfaces. The local inflammation and fever, instead of being slight, and only of a few days' duration, may assume a more alarming form, affecting the stump and all the organic functions, including the sensorium or cerebral centre, attended by perspirations and rigors, foul tongue, arrested secretions of skin and bowels, and either an ineffective suppurative action of stump, or a total absence of all effort. If suppuration during this struggle is developed freely in the stump, there is general improvement, temporary or permanent; if temporary, the suppuration is arrested; sympathetic pains of abdomen; alternate excitement and prostration follow; leading, finally, to a state of coma, to relaxation of the sphincters, and death. A more or less diseased state of stump is generally found to have existed, and occasionally phlebitis. The result forms the corollary to the antecedent conclusion given in a former lecture, viz., that *pain* will effect a deleterious impression upon the nervous centres, disturb the vital functions, and destroy life, *without organic disease, or time for its development.*

Amputation thus produces, as the simple and unmixed effects of the operation, general and local inflammatory action, apparently induced, or at least accompanied by a more or less powerful impression upon the nervous centres; and the usual means adopted by nature for the relief of the system and cessa-

tion of this action is, by establishing the process of suppuration from the whole or a part of the surface of the stump.

We pass on to determine the effects upon the system of amputation, superadded to long pre-existing local disease of the extremity amputated.

The only records to which I have been able to refer you on this head, have been those of the amputations of the hospitals of Massachusets and Pennsylvania, and more lately one from the Glasgow Infirmary. The former only furnishes the mortality, the latter gives some partial information as to the diseased actions causing death.

Effects of Amputation in Cases of Chronic Local Disease.

We found the mortality, in the two American hospitals, to be, in 48 of the lower extremities, 1 in 6; in 10 of the upper, no deaths.

At the Glasgow Infirmary, in 127 of the lower extremity, the mortality was 1 in 4; in 23 of the upper, nearly 1 in 6.

The mortality is considerably greater in the Glasgow Infirmary, which Dr. Lawrie attributes, and probably with much reason, to the pseudo-improvements of late years in surgery, by which we are led to believe cases curable long after they have ceased to be so; and defer having recourse to amputation, until obvious signs of dissolution threaten, at no remote period, to remove the patient, who is thus sacrificed to a vain effort to save a limb which does not admit of cure.

In both series the proportion of lower extremities amputated was quintuple that of the upper; showing the greater prevalence of disease in the lower extremity, and especially of the leg.

In reference to the CAUSES OF DEATH, the diseased actions are stated only in 17; 14 of these died from secondary inflammation, and 7 of the latter number with purulent depôts; 1 from cerebral effusion, and 2 from secondary hæmorrhage. Thus, if we take the operations of the three civil hospitals combined, forming a gross total of 208 cases amputated for disease, of which 43 died, the proportion is 1 in 4.8. The average mortality is thus stated, as applying to unfavourable cases for treatment, under more or less favourable circumstances.

Upper extremity .... 33.. 4..1 in 8.2.
Lower ditto .....175..39..1 in 4.4.

The majority of deaths apparently occurring by secondary inflammations, showing more or less structural change. These are the results of the operation of amputation, superadded to a long-continued local disease.

Effects of Amputation performed for the Injuries of Civil Life, compared with the Results of Amputation for Gunshot Injuries.

In reference to injuries of civil and military life, the infliction of which must ever cause a shock somewhat analogous probably to that of amputation, we have traced the effects of the injury on the limb and the system, noted the differences between the effects of similar classes of injury in military and civil life, and under a great variety of conditions.

We have only now to retrace the effects of the double shock caused by the original injury and by amputation,—and the variations observable in proportion as the second shock of operation succeeds the first, occasioned by the injury, at a longer or shorter interval. How these effects again may be modified by varying conditions, in reference to the nature and degree of the wound, its site, the external circumstances, the dynamic influences under which the operation may be performed, and the subsequent treatment conducted.

The first classification, in reference to the nature of the injury adopted in these cases, was, into the injuries of civil life; such as are caused by the fall of stones, the passage of wheels of carts or carriages, and the accidents resulting from machinery, and those of military life, consisting chiefly of lacerations and fractures from musket, grape, and cannon-shot, or by explosions of gunpowder, shells, and rockets; more rarely by incised and bruised wounds from the sabre.

The necessity for this distinction does not appear at first very obvious, since in both military and civil life the more complicated injuries, of which I have above spoken, are alike compound, and more or less comminuted fractures, each usually attended with more or less bruising and laceration of soft parts, each liable to rupture of vessels, &c. But I have been led to believe, that there is a most important difference in the results obtained from the treatment of the two classes in the respective hospitals, due in great measure to a difference in the impression made by the original injury on the mind and nervous system of the sufferer. That the injuries of civil life and the amputations for them, especially those performed in the primary period, are followed by more unfavourable results than equally grave injuries occurring in the field.

The returns of the civil and military hospitals, to which I referred you for data, confirm this opinion. If we reflect for a moment upon the mode in which the two classes of injuries are inflicted, I think an adequate reason will suggest itself. A man employed in some agricultural or manufacturing occupation, if he becomes the subject of a grave injury, it must be under circumstances for which his mind is totally unprepared, under circumstances the most calculated to cause terror and alarm, and a great shock, mental and physical. He is dashed down, trodden under horses' feet, and the wheels of the vehicle pass over him, or he falls from a scaffolding; the feeling, the instinctive dread of sudden death, must be strong

upon him during these moments, few as they may be; and when he is extricated from his imminent peril, stunned, severely bruised, he wakens to consciousness to find that a limb is crushed, and his only chance of life is to submit to its removal by a dreadful operation: so of the accidents of machinery, what can be more frightful or more calculated to inflict an irrecoverable shock on the nervous system—a deleterious one, inevitably—than for a man to feel caught by a fly-wheel, whirled aloft, and his arm torn from his body?

In military life, the injuries inflicted are under very different circumstances; it is true, men but the moment before with sound limbs and in full health, fall with bones crushed and broken, with limbs torn from their bodies. But every man goes into action knowing his liability to such occurrences; he sees his comrades fall on every side; many he sees bear it almost gaily — the majority with good courage; he has known hundreds to whom the same lot has fallen recover, and either return to their duty, or pass the rest of their lives not unhappily with a pension. He is excited at the moment; the onward rush, the shouts of the victors and the vanquished mingling with the roar of artillery, the flashing peals of musketry, all tend to make him reckless of any feeling, but one of wild excitement or enthusiasm. I have seen a man with his arm shot away cheering his comrades, unwilling to walk to the rear for medical aid until he saw the result of the charge; others have walked to me on the field, and requested me calmly to relieve them of the lacerated fragments of a limb torn away. The immediate shock of the injury is often, therefore, trifling in some of the worst injuries; and if a musket-ball strike him, he is often not conscious of what mischief it may have done. There are exceptions, particularly in regard to the injuries arising from shells and cannon-shot; but the general features marking the *first effect* are thus widely distinct in the majority, where the extremities alone are involved.

The injuries of civil life received into the hospitals, on the other hand, possess this great advantage, that they are always treated under favourable circumstances in establishments provided with abundance of means at the surgeon's disposal. The only proper comparison that can be made, therefore, is between the results of gunshot injuries treated or amputated under favourable external circumstances.

In reference to those *treated without amputation*, you have seen that in military hospitals in eight doubtful and unfavourable cases of injuries to the upper extremity, treated under favourable circumstances, the mortality was 1 in 2.6. Two out of the three deaths being occasioned chiefly by complicating wounds of chest; the remainder of the six cases being injuries of joints, of which only one died. In nine of the lower extremity, nearly equally divided between fractures simply and those involving joints, the mortality was 1 in 2.2; the four deaths occurring exclusively in the joint injuries. The mortality then, where the upper and lower extremities were in nearly equal proportions, exclusive of two cases having fatal wounds of chest, was 1 in 3. Whereas, in Dr. Lawrie's return of forty cases treated for the complicated injuries of civil life, the mortality was 1 in 2.2, with scarcely a fractional variation between the proportion of deaths in the upper and lower extremities.

In reconsidering the *Effects of Amputation* in each class, we shall see this result confirmed, and the preceding observations fully borne out.

Mortality of Amputations in Civil Hospital.

In the two American hospitals, the primary amputations give a mortality in forty-three cases of the upper extremity of 1 in 5.6; in the lower, 1 in 3.2, Dr. Lawrie gives a much less favourable return of the Glasgow Infirmary; in forty-one of the upper extremity, the mortality is 1 in 3.1, and in the lower extremity it is 1 in 1.7. The mortality, therefore, is about doubled. In the upper extremity, the difference is in the arm; a proportion of one-third dying in America, and one-half at Glasgow. In the lower extremity, ten-elevenths died in the thigh, and nearly three-fourths in the leg, at Glasgow; whereas in America only about one-half of the thigh amputations were fatal, and *only* 1 *in* 14 *of the leg!* I call your attention more particularly to the last fact, because Dr. Lawrie is disposed, incorrectly I think, to consider the amputations of the leg more fatal than those of the thigh, as in the series before him, amputated for *disease* it proved to be, and he endeavours to account for it. By what combination of circumstances they were so fatal in the Glasgow Infirmary, it may be difficult to say; but that they are not habitually or usually more fatal, quoad the *amputation*, is a fact placed, I should say, beyond doubt. I confess it seems to me, that no case is made out why the operation "below the knee" should be abandoned; while all the reasons which have induced surgeons to leave no superfluous length of limb, remain untouched.

Mortality of Amputations in Military Hospitals.

In a series of primary amputations for injuries of the field recorded by Mr. Guthrie from the battle of Thoulouse, and another series recorded in the hospitals under my charge, both series treated under fairly favourable circumstances, the mortality in the upper extremity you have seen was 1 in 9.5; in the lower, 1 in 4.7: which, compared with the most favourable results in civil hospitals before us, gives a proportionate suc-

cess not far from double that obtained by amputations for the injuries accruing from railroads, machinery, &c. And if we take the average of the least successful, those of the Glasgow Infirmary, the mortality in the primary amputations of the military hospitals is two-thirds *less* in both the upper and lower extremity.

Thus, in reference to the injuries of civil and military life, it is evident that the mortality of primary amputation for the former is at least doubled; and sometimes the deaths exceed those resulting in military life by two-thirds. There must be a cause for a difference as constant as it is great.

The same result, however, does not hold good in the cases usually clubbed together as *Secondary amputations*, that is to say, all those performed after the primary period.

In the American civil hospitals, the mortality is 1 in 11 in the upper extremity; 1 in 2.2 in the lower. In the military hospitals before specified, in the upper it is 1 in 4.6, in the lower 1 in 2.

Mark the conclusion, the primary amputations for injuries of military life, which, compared with those of civil life, presented a mortality less by one-half; in secondary amputations give the reversed conclusion of being twice as fatal in the upper extremity, and a fraction more fatal in the lower. Take even the Glasgow Infirmary, which gave the least favourable view of the results of amputation for the injuries of civil life; the secondary amputations give a mortality in the upper extremity of 1 in 2.4, and of 1 in 1.5 in the lower; and we find that, although still presenting collectively a greater mortality than the military hospitals, the disproportion is much diminished; and, compared with the results of the primary amputations in that institution, you will find that the secondary amputations of the thigh and leg are much more successful—in a striking degree, instead of ten-elevenths and three-fourths dying, the mortality is two-thirds, and in the leg a trifle less. There is but little change in the upper extremity.

The results of amputations in civil hospitals for chronic local disease, where there is only one shock sustained, although the limb be much diseased, gives a much smaller mortality than either *primary* or *secondary*.

If we take the civil hospitals altogether, there can be no doubt that the relative success stands thus: 1. Amputations for chronic local disease. 2. Secondary amputations for injury. 3. Primary amputations.

This order can only be reversed and brought *partially* to that established by the army surgeons by reference to military hospitals, containing a class of injuries which, however analogous in some points, present to the philosophic inquirer very important differences, calculated to exercise, as they are thus demonstrated to do, great influence on the results of amputation. Thus may it be proved that a one-sided view has alone been taken by civil surgeons, with John Hunter at their head, in 1790, and by army surgeons who closed the record of results some twenty-five years later, including Messrs. Larrey and Guthrie as the two principal recorders. Of the two advocates, John Hunter approached nearer the truth; for he adopted a correct principle in stating that a man was not in a state the nearest approaching to health a few hours after receiving a severe shock from an injury, and that he may be in a more favourable state for an amputation and its second shock at a subsequent period; whereas in trying to reconcile facts to a theory—a labour the military surgeons undertook—they upheld a doctrine which I believe to be untenable, and, applying the experience of the field to civil hospitals, they fixed a practice upon civil surgeons in opposition to *their* facts and daily experience, from the trammels of which they have never made the effort necessary to release themselves. A large and comprehensive series of observations would soon have demonstrated *error* somewhere in the principles of the army surgeons, when applied to the treatment of the injuries of civil life, leaving the *experience* and the *facts* of the army surgeons untouched (as applying to military life), yet showing them inapplicable to civil practice.

Let us include the results of military hospitals. You will find, then, indeed, the order of the military surgeons in part re-established. But the results of civil hospitals reverse all their theories as to the state in which the patient bears best the shock of an operation. In them the first rank is unavoidably assigned to amputations performed on subjects *far from a state of rude health*. This they maintain to exist immediately after the violent shock of an injury, and next declare it to be the *chief cause* of *success* in primary amputations on the field over all performed at subsequent periods.

The results of military and civil hospitals combined stand in the following order:—

First. Amputations for chronic local disease.

Second. Primary amputations for injuries of military life.

Third. Secondary amputations for injuries of civil life.

Fourth. Primary amputations for injuries of civil life.

Fifth. Secondary amputations for injuries of military life.

The question of primary and secondary amputation is here reversed in military and civil life. The main doctrine on which the army surgeons explained and upheld the superior excellence of primary amputation and its universal application (viz., the rude health of the patient), is shaken to the centre

by the most successful of all the series of cases, proving to be those performed where long pre-existing disease and often confinement has removed the patient far from a state of robust and plethoric health, to one of debility and emaciation.

Is it not strange that the medical practitioners of civil life, of large cities, whose talents are employed in large institutions, where hundreds of cases of amputation for injury and disease, in a few years must pass under their observation, should for so long a period have accepted doctrines and results, the first fallacious, and the latter inapplicable, and to which the facts and experience of their own practice are totally opposed?

Question of Primary and Secondary Amputation in Reference to the Injuries of Civil and Military Life decided by Results.

It is only within the last few years that any inquiry seems to have been awakened. Four years since I myself ventured to call in question the accuracy of those views which decided a primary period to be always the best for amputation, and the doctrine that it was so, because the patient was at such time in a state the nearest approaching to health. This doubt had been long suggested by the effects which I had observed, were developed in primary amputations for gunshot injuries, and without peculiar reference to the results in civil hospitals. But reference to the results of amputation in civil hospitals more than suffice to confirm those doubts.

Within the last few years, independent of the records of the two American hospitals and of the Glasgow Infirmary, various results have been published, calling the attention of the profession to facts opposed to the prevailing doctrines on amputation.

M. Gendrin, in 1835, gave, in a thesis, the result of sixty amputations performed in Paris, in which they took the following order as to success:—

First. Chronic disease.
Second. Secondary amputations.
Third. Primary.

And although the mortality was excessive in all, still thus they stand.

In 20 amputations performed on children for chronic diseases in 1834, all recovered.

In reference, then, to amputation, what are the first conclusions to which these facts lead? The details have been stated and analysed, and when laid before you, the inferences from each were deduced. In their most condensed form they are these:—

Conclusions on the Relative Advantages of Primary and Secondary Amputation for the Injuries of Civil and of Military Life.

First. Between the injuries usually received into civil hospitals of a nature to require amputation, and those occasioned by the casualties of the field, an essential difference exists, exercising a most important influence upon the progress of the case and the results of amputation.

Second. This difference consists chiefly in the greater shock, moral and physical, generally caused by the *infliction of the injury* in civil life, from which the patient does not sufficiently recover in the first twenty-four hours to bear the second shock of an amputation; hence is this first period less favourable for the operation, than one more remote, when the alarm has ceased, the febrile action had time to develop, and to be finally relieved by the suppurative process.

Third. In proportion as this first shock or alarm is great in the injuries of military life, are the results produced the same. Hence amputations for wounds from cannon-shot and shells more nearly approach in their effects to the injuries of civil life. It follows that it may often happen in military practice, that the system is not seriously implicated within the first few hours, and amputation may be advantageously performed; while in those of civil life, amputation within twenty-four hours adds a second violent shock to the nervous system generally, while the patient is still under a strong deleterious action from the first; and the result is either death by shock, or by the development of violent febrile action, by phlebitis, secondary inflammations, tetanus, gangrene, &c.

Fourth. Extensive experience proves that where a violent commotion has been sustained, deeply involving the nervous centres and the *morale* of the patient, the operation is better borne after the suppurative process is established. In gunshot injuries, however, where the whole of the structures of a limb are involved by the lacerating course of the ball and the excessive comminution of bone, added to the jar or shock communicated by the crushing force of the ball in contact, a more fatal and extensive action is developed, leading to greater irritation and exhaustion in the system than the ordinary injuries of civil life: thus operation in a subsequent period proves less successful than when performed in civil hospitals.

Fifth. The result of amputations performed for long-existing disease of a limb, often after exhausting suppuration has been long continued, the patient emaciated and greatly debilitated, prove incontrovertibly that this is not an unfavourable state for the success of amputation, the supervening actions are generally less fatal in character, less violent in their development.

These conclusions indicate the principles of practice in reference to the casualties of civil and military life, and are strongly supported by all the facts which the preceding lectures have brought under your notice.

Influence of Modifying Circumstances on the Results of Amputation performed for Gunshot Injuries.

We have yet to trace the influence exer-

cised on the results of amputations by such variations in the nature of the injury as prevail in the casualties of military life, such for instance as the period at which the operation is performed, the site, the external and dynamic conditions attending the operation, the subsequent treatment, and, finally, the mode of operation, after dressing and treatment. Those influences will be judged by two orders of effects: first, the proportionate mortality; and, secondly, the nature and course of the diseased actions, which are the immediate cause of a fatal result.

The classes under which we may best consider the variations in the nature of injuries as regard amputation, are the same as those adopted in considering the same injuries under treatment. Injuries of joints—injuries only fracturing the shafts—injuries favourable, doubtful, or unfavourable, in reference to their fitness for treatment and cure. These have to be considered in reference to periods of amputation, which are three; the *primary*, before the supervention of febrile action; the *intermediary*, from its supervention to its abatement or cessation usually marked by the full development of suppurative action; and *secondary*, any subsequent period before the healing of the wounds. Let me recall to you the chief characteristics of the progress and results of operations performed in each of these periods.

Primary [Mortality] Amputations,

In military life, we have seen, are the most successful. The series I selected for analysis consisted of 57 cases performed in the hospitals under my charge, the majority in the same locality in twelve consecutive months; of these, 29, or more than one-half, died. Thus you saw that even primary amputations for gunshot injuries are liable to modifications in their success, even if you had not seen that in one series of 18, 15 died. The same causes which influence the primary, may probably modify the results of amputations performed in the intermediary and secondary periods. In reference to external circumstances and dynamic influences prevailing during the treatment of amputations, I stated that I had always observed that, when these were highly unfavourable, the consequences seemed to fall more heavily on the primary than the secondary, not only reducing the favourable balance, but occasionally giving the advantage to the secondary, while the intermediate amputations all perished. Under favourable circumstances, on the contrary, the order in rates of mortality beginning with the most successful, is, first, primary; secondly, secondary; thirdly, intermediary.

Thus, in proportion as the circumstances are favourable, is the preponderance of success in primary over all subsequent amputations; but, as those circumstances become highly unfavourable, the preponderance diminishes, until at last the secondary become the least fatal; the order is, then, secondary least, primary next, intermediary all fatal.

An obvious difference, however, is observable between the effects of unfavourable circumstances, when these are external and physical, and when they are of dynamic character affecting the morale of the patient. Of 36 amputations, under more or less unfavourable circumstances, 18 were performed under distressing and highly-deleterious dynamic influences. To ascertain, therefore, how far physical circumstances influence the result, when there is no other unfavourable influence predominating, I separated the 18, and considered the mortality and diseased actions supervening on the remaining 18, of which number 10 died. The different mortality of 15 in 18 and 10 in 18 alone indicating an influence in the one, not existing in the other. In 21 primary amputations performed on the field and in hospital under favourable circumstances, 4 died, or 1 in 5.

Primary Amputations.

			No. of Cases.	Deaths.	Proportion.
Under favourable circumstances .... 21 (9 of the thigh)		Upper extremity..	11	1	11.
		Lower ditto ..	10	3	3.3
Under more or less unfavourable ditto 36		Upper extremity..	21	13	1.6
		Lower ditto ..	15	12	1.2
			57	29	1.3
But if we analyse further, 18 were under deleterious dynamic influences 18		Upper extremity..	9	7	1.2
		Lower ditto ..	9	8	1.1
And 18 under unfavourable external influences only 18		Upper extremity..	12	6	2.
		Lower ditto ..	6	4	1.5

Thus merely external circumstances, when unfavourable, increase the mortality in the upper extremity more than five times; in the lower it doubles it. But when to temporary and but partially unfavourable external circumstances are added deleterious dynamic and moral conditions, the mortality averages, in the upper and lower extremity, from seven-ninths to eight-ninths of the whole number amputated. In each of the three conditions the more they are unfavourable the less difference is there between the relative mortality of upper and lower extremity. Thus, under

Favourable conditions 10 in 11 are saved in the upper.
„ 1 in 3.3 in the lower.
Unfavourable physical..1 in 2 in the upper.
„ 2 in 3 in the lower.
Unfavourable dynamic in addition.....1 in 4.5 in the upper.
„ 1 in 9 in the lower.

Thus much for the mortality under varying external and dynamic influences, and in reference to site.

Nature of Diseased Actions causing Mortality.

We found their nature changed also in different circumstances.

In the 29 fatal cases in 57 primary amputations—

4 occurred under favourable circumstances.
10 under unfavourable physical and collateral circumstances.
15 under partially unfavourable physical, but predominating unfavourable dynamic influences.

The diseased actions in the 4—
1 irritative fever; no organic disease.
1 bilio-remittent; phlebitis.
1 phlebitis and purulent depôt in a joint.
1 necrosis and vomicæ of lungs, &c.

In 10—
3 irritative fever.
2 cholera.
1 tetanus.
1 hectic.
1 bilio-remittent.
2 febrile type not ascertained.

10

In 15—
10 bilio-remittent; 5 arm, 5 thigh.
9 with diseases implicating viscera; 4 of thigh.
1 abscess of thigh.
Disease of lungs and liver in 4; of lungs only, 4; of liver only, 1; phlebitis (arm), 1.
2 irritative fever; phlebitis in both, abscesses of lungs in 1.
1 hectic, phlebitis.
1 type doubtful; abscesses in lungs, liver, and shoulder-joint.
1 shock of operation.

15

The chief difference to be observed when dynamic influences of unfavourable character prevail, therefore, is the large preponderance of bilio-remittent type of fever; of purulent depôts in distant parts and in the viscera; finally of phlebitis. These occur in each of the other conditions, but in different proportions. These latter fatal actions occur in pretty equal proportions in upper and lower extremities. If we look, therefore, at the causes of death in the whole 57 primary amputations, the chief actions in 29 fatal cases run in the following numbers:—

13 bilio-remittent; all (except one not examined) with secondary diseases of viscera, or with purulent depôts in the limbs.
5 irritative fever, 3 in like manner complicated, and 2 with phlebitis.
2 hectic fever, 1 with phlebitis.
1 purulent depôts of lungs and liver, with no distinct febrile type.
1 phlebitis, ditto.
2 cholera.
1 shock of operation.
1 tetanus.
3 causes not clearly ascertained.

29

Compared with the causes of death in 38 cases not amputated, we have the effects of one shock in the injuries treated; and the diseased actions resulting from two, quickly succeeding each other in the primary amputations. The actual proportion of the febrile and the irregular actions is not very different, but the remittent is predominant in amputation; the hectic in cases dying under treatment. The proportion of irritative fever in primary amputations is about that of the remittent in fractures. The proportion of tetanus and shock is more than doubled in cases treated.

As to proportion of secondary inflammations, abscesses, &c., in 21 febrile cases in fractures treated, they were proved or suspected in 9—nearly *one-half*. In primary amputations in 20, 15, or three-fourths. In 14 fatal cases from irregular action during treatment for the injury, 5, or nearly one-third, were ascertained; after primary amputations in 9, 2, between one-fourth and one-fifth. Combined, the number of secondary inflammation and depôts, 14 in fractures, 17 in amputations, shows a proportionate difference of 1 in 2.5 to 1 in 1.7. Phlebitis, of frequent occurrence in primary amputations, is rarely met in injuries treated. Secondary hæmorrhage, shock, tetanus, gangrene—some either do not appear at all in the causes of death in primary amputations, or in much smaller proportion than in cases treated.

Thus it is evident that while primary amputations are less endangered by the four above-mentioned irregular actions than cases treated, they are infinitely more obnoxious to the worst form of fever and the worst complications, viz., secondary inflammation, purulent depôts, and phlebitis. And while more than half the cases of injury treated perish, without trace of organic disease or lesion of any important viscus, scarcely one-sixth die after primary amputation, without leaving trace of structural change in the viscera or venous system.

The conclusion arrived at from a consideration of the two sets of unfavourable cases of primary amputation, is, that there are two classes of causes materially influencing the development and character of diseased actions

supervening on primary amputation, and consequently on the mortality of such operations—the one moral and dynamic, the most fatal and difficult to combat, and the most subtle in its characters. The second are physical, and generally sufficiently obvious. Under the first of these, bilio-remittent fevers, purulent depôts, and secondary inflammation, are at once the most frequent and fatal consequences; and the mere physical and external conditions under which primary amputation is performed, and subsequently treated, exercise little or no direct influence upon the development of the peculiar class of diseased actions, which are probably dependent upon a dynamic order of causes, acting chiefly through the nervous system. The same effects, but in smaller number, are observed, under such circumstances, to supervene on the same injuries treated without amputation.

Primary amputation, performed under unfavourable circumstances, is an operation under which the system becomes highly susceptible of supervening actions fatal to life, and its susceptibility, as well as the deleterious nature of the actions, seems to be in relation to the violence of the shock communicated either by the injury or the quickly succeeding shock of the operation. Thus precisely the same results may follow the one or the other, whether occurring in the upper or the lower extremity.

If the shock be really severe, therefore, it is sufficiently demonstrated by the primary amputations in civil life, that the body is not in the best state for its successful issue; and that as a state of chronic local disease seems by no means to place the patient in an unfavourable state for the single shock of an operation, it is easy to understand how cases selected from those patients who, after an injury, survive beyond the inflammatory stage, without serious organic disease, with a local disease as the chief result of the first shock, do actually present a more favourable condition for the success of amputation, than within the first twenty four hours of the infliction of a violent shock.

Conclusions in reference to Amputation performed in Intermediary and Secondary Periods. Mortality and Nature of Diseased Actions.

In 27 amputations in the intermediary period, 17 died.

		Mortality.
13 upper extremity ..died	8....	1 in 1.4
14 lower ditto	9....	1 in 1.5
27	17....	1 in 1.5

Tolerably equally divided, both as regards circumstances for treatment and numbers of each extremity.

7 died from irritative fever; 4 bilio-remittent; 3 fever, less defined; 3 trismus.

Secondary hæmorrhage occurred in 1; phlebitis in 3; secondary inflammations or purulent depôts in 5; tetanus in 3. The proportion of these complicating actions was 1 in 1.58.

In 25 secondary amputations—

Upper extremity ...	8....	1....	1 in 8.
Lower ditto.....	17....	8....	1 in 2.1
	25	9	1 in 2.7

5 died of shock, or nearly one-half, aided in 3 by secondary hæmorrhage; sloughing of stump, and hectic.

1 exhausted; 1 hectic and diarrhœa; 1 erysipelas; 1 irritative fever, with secondary hæmorrhage.

Secondary hæmorrhage occurred in 2; phlebitis in *none*.

Secondary inflammation and abscesses in *none*; tetanus in *none*.

Shock in 1 in 3.5 was the leading cause superadded to a low hectic fever.

The complicating actions, therefore, were in larger proportion than in any other class; yet three of the most fatal actions are not present.

Drawing our conclusions from 93 deaths occurring, constituting the four classes of cases, viz.:

38 fatal cases of injuries treated without amputation.
29 fatal cases of primary amputation.
17 fatal cases of intermediary amputation.
9 fatal cases of secondary amputation.

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Comparative Results in reference to leading Causes of Mortality.

We found that the primary amputations were more obnoxious to secondary inflammations and depôts, and visceral disease, than intermediary; while the liability of the latter to phlebitis was about equal. That fractures are less liable than either to the purulent depôts, diseases of viscera, &c.; and no case of phlebitis was traced in the whole series of 38 deaths occurring among the injuries treated and not amputated. Lastly, that if secondary amputations were not exempt from three of the most fatal of the whole range of the supervening actions, viz., phlebitis, secondary inflammations of viscera and purulent depôts, and tetanus, they were at least by no means equally liable.

Hectic supervenes, and is occasionally fatal in three of the classes; it is in equal proportion in the injuries treated to the end, and secondary amputation—more than 1 in 4 died from its effects, while it does not appear in intermediary amputations.

Irritative fever is common to all—almost the only action of which this can be said, but its proportions vary. It is least prevalent in cases treated, 1 in 15; in secondary next, 1 in 9; it is in largest proportion in intermediary.

Secondary hæmorrhage occurs in all, most frequently in secondary amputations, 1 in 4.5.

Tetanus is most frequent in intermediary amputations, 1 in 5.6; next in fractures treated, 1 in 6.5; in primary amputations, only 1 in 29.

Shock, or that impression on the system from which the patient evidently never completely rallies, is a fatal effect in all, carrying off one-half of the secondary amputations when the operation is performed in an exhausted and hectic state. In injuries treated it is 1 in 12, and only 1 in 29 in the series of primary amputations. The proportion of those who die by the immediate and palpable effect of shock, I have already remarked to you, is not large, except in the worst kinds of cannon-shot injuries, or with many complicating wounds. But the number who die of its less obvious or sudden, but not less certain effects, is in a much larger proportion than these figures convey, which only refer to the patients who die within twenty-four or forty-eight hours.

In reference to the intensity of actions, as shown by the average duration of life after operation, the average term of death in intermediary amputations is 14 days; in secondary, seven days; yet the most destructive actions prevail in the intermediary, with the single exception of shock. When cases of intermediary amputation terminate fatally, they do so by vigorous attacks of febrile and inflammatory actions, as stoutly resisted in the first instance; the secondary sink, by the continuance of the enfeebling and exhausting actions which led to the operation only as a last resource; and when the powers of the system are too far gone to resist the shock of an operation, the patients sink, in a period varying from a few hours to six or seven days. In intermediary amputation the disease is more intense, but so is the frame stronger, and their fatal development requires an average term of from twelve to fourteen days.

If all amputations performed after the primary period be taken together, the average term for the fatal development of diseased actions supervening, is for the upper extremity fifteen days and a half, for the lower eight. The period lengthens as the injury becomes less severe; amputation for injury of the radius, ulna, and hand, give an average of nineteen days.

Excepting the prominent part, however, played by shock and by secondary hæmorrhage in the lower extremity, the actions do not differ in their nature, in this lies the chief distinction: three-fourths of the lower extremity are carried off by actions of which shock forms a principal feature, while in the upper extremity death from shock is very rare.

On this part of our subject I only think it necessary to recall the chief and peculiar dangers of each of the four classes.

In complicated injuries of the extremities, for which amputation is not performed, the prevailing actions and causes of fatal result are,—

1. *Bilio-remittent fever*, with complications, chiefly purulent depôts, secondary, intermediary, &c., but *not* phlebitis.

2. *Hectic fever*, with its most usual complications, diarrhœa, sloughing, and unhealthy, local, suppurative, and disorganising actions.

3. *Irritative and continued fever*, with other forms, and attendant unfavourable local actions.

4. *Shock and tetanus.*

5. Secondary hæmorrhage, disorganised limbs, mortification, &c. Nos. 4 and 5 may be classed as accidental complications.

Thus these injuries under treatment are liable to the action *of all the causes* supervening on three classes of amputation save one—phlebitis; and liable, moreover, to actions from which secondary amputation in the series before us are exempt.

Primary amputations. — Bilio-remittent, with complications of purulent depôts, &c. (not phlebitis), largely predominates, most so under unfavourable dynamic influences, but it occurs in all sites and under all circumstances. *Irritative* fever, with similar complications, and phlebitis: these are the two leading causes of death. In nearly one-half, secondary inflammations, involving viscera, occur, and between one-fourth and one-fifth laboured under phlebitis.

Primary amputation, then, is liable to each of the causes of danger and death which are observed to supervene in all the classes under consideration, the most dangerous in the largest proportion.

Intermediary Amputations.

But little difference, you have seen, existed between the character of the supervening actions in intermediary and primary amputations. I have been led to believe that there is a greater proneness *in primary amputations to take on any diseased action which may be prevailing at the time.*

In *Secondary* amputations, shock with the prevailing hectic, and diarrhœa, are almost the only important supervening actions to be dreaded. These cases are infinitely less exposed to all the more fatal actions attending the other classes. If the patient escape the immediate effects of the shock, there is every reason to anticipate his total escape from the many other diseased actions of fatal character supervening on injuries treated, and primary or intermediary amputations.

These are the conclusions arrived at by strict analysis and careful study of a large number of cases. To endeavour to recapitulate the conclusions, in reference to the *causes and progress* of the diseased actions I have enumerated, would carry me too far. The result I would enforce in reference to the principles of practice, is the necessity of determining the question of treatment or am-

putation at different periods, in reference not only to the nature of the wound, but to the shock experienced by the infliction of the injury. Wherever it has produced a violent commotion, as in the accidents of civil life; more rarely in gunshot wounds, primary amputation is full of peril. In military life, if external and dynamic influences be favourable, there can be no doubt that in the greater part of the worst cases, including cannon-shot, even when the shock has been great, if the patient rally at all effectively within the first twenty-four hours, a great saving of life will result from primary amputation in the upper extremity, and rarely less than two-thirds even of the lower, will be saved. It is not so after the great commotion, the terror and the shock, moral and physical, succeeding most of the graver accidents of civil life. The most favourable returns show a mortality of one-sixth in the upper, and one-third in the lower extremity; the least favourable is one-third in the upper, and two-thirds in the lower, $\frac{10}{11}$ths of the thigh dying. These, compared with the secondary amputations of each institution, show a decided advantage in favour of the latter. Thus in civil life, even if we add to the mortality of secondary amputations, those deaths which occur in the intermediary period, there is still much reason to believe that the absolute mortality would be diminished, if no primary amputations were performed.

In military practice, on the contrary, the whole of the facts tend to prove the superior advantage of primary amputation, except under one condition, viz., under temporarily unfavourable physical circumstances; when to these are added *deleterious dynamic influences*, and where the morale is depressed and unfavourably acted upon. The result of the March series, where only three cases were saved out of eighteen, sufficiently proves, when compared with the results of those treated and not amputated in the same period, even allowing that the latter were among the most favourable cases, that a much greater amount of life would have been saved, had the operation been deferred to a secondary period.

Under unfavourable circumstances, the great advantage observed to belong to the results of amputation of the upper extremity, over the lower is nearly lost. The mortality falls nearly equally upon both.

Again, under unfavourable circumstances, intermediary amputations no longer offer any hope of saving life: the few that are saved are always under favourable circumstances.

Decidedly unfavourable conditions and circumstances have in proportion less influence on the results of secondary amputation, than in either of the other classes. Thus, if the patient's strength be not utterly exhausted, so that there is every probability that the first shock will at once prove fatal, the operation often succeeds against all ordinary calculations, the actions destructive of life are very few (shock, hectic, secondary hæmorrhage); the latter occurring in one-fifth of the cases; and if the operation were performed as soon as the suppurative action is fully established, and the fever subsided, the numbers saved both in military and civil practice would be greater than is usually observed when treatment is generally too long persisted in.

Influence of Modes of Operation. Dressing and After-Treatment.

I devoted the last three lectures to the consideration of the influences due to different modes of operating, of dressing of the stump, and of after-treatment, testing the flap and circular modes by relative rates of mortality, and the proportion in which various unfavourable diseased actions supervened in each. The following conclusions resulted.

The mortality is somewhat less in operations by circular incision than by flap, in both in the upper and lower extremity, in favourable and unfavourable circumstances, primary and secondary.

Primary.

	Mortality. Lower Ex.	Upper Ex.
Amputations by circular incision under favourable circumstances ..	1 in 3	1 in 7
Amputations by flap incision under favourable circumstances ..	1 in 2	1 in 4
Amputation by circular incision under unfavourable circumstances	1 in 1.2	1 in 2
Amputation by flap incision under unfavourable circumstances ..	1 in 1.2	1 in 1.7

Flap operations we found less liable to secondary hæmorrhage, particularly in the lower extremity and in secondary amputations; but in primary amputations, if the whole number be taken, the advantage would seem in favour of the circular incision. Under favourable circumstances the cases of secondary hæmorrhage in circular operations is doubled; under unfavourable, the flap has a larger proportion than the circular, but not in the upper extremity.

It would seem that the flap is more adapted for the lower extremity in favourable circumstances, and for the upper in unfavourable; but these results want confirmation by the results of very large series.

No obvious influence was traced on exfoliation or tendency to conical stumps. In reference to period of healing we found the flap had the advantage, and in *secondary amputation* this advantage is considerable: in flap the average period was sixty days, in circular ninety. In the injuries of civil life, the circular operation exhibits a considerable advantage over both; but there are no

flap operations to compare with these in the same institutions.

The most important of the results derived from this analysis of results the in two modes of operating, was the greater liability of flap operation to the supervention of phlebitis, secondary inflammations, and purulent depôts.

This coupled with the greater mortality, which is probably the effect, seems to more than counterbalance any of the advantages observed, and lead to the conclusion that the flap is only preferable in certain exceptional cases and conditions such as I indicated.

In reference to torsion and short-cut ligatures, they possess no advantages over the more usual mode, and some grave inconveniences are attached to their adoption.

One word more on the putting-up of stumps, and especially the delayed dressing; its *disadvantages are great and certain;* its *advantages at best doubtful.*

Union by first intention I showed you while it was not a safeguard to the supervention of the worst consequences, in bad actions, local and general, often exercised a most injurious influence upon the results favouring the development of inflammatory action, which nature invariably attempted to relieve by establishing a suppurative process in the stump.

The conclusion from such considerations is, that the indiscriminate endeavour in all cases and circumstances to obtain union by first intention, is condemned by the results as *injudicious, unscientific, and often highly prejudicial.* In reference to this subject, I defined three classes of cases authorising and requiring three different modes of dressing, as those best calculated to promote the success of the operation, in the anxious hope that a treatment, modified upon fixed principles in reference to the *nature of the cases,* will attract the serious attention of the profession, and ultimately meet with the favour but too often reserved only for extreme and sweeping measures, and a routine of treatment which, if fitted for one set of cases and circumstances, is totally inapplicable to others differently characterised.

I cannot conclude without expressing an earnest hope that the profession generally, and more especially hospital surgeons, whose opportunities in all countries are great, of making extended observations, and of collecting the most accurate records of a large number of cases, may be induced carefully to reconsider the grounds on which the prevailing doctrines, in reference to the treatment of complicated injuries of the extremities, and the expediency of amputation at different periods in civil and military life, are founded: that they will put them to the tests obtained by the analysis of the results of large numbers of cases. The united labours of hospital surgeons and others to thoroughly investigate the subject upon their accumulated records, would soon remove all inconsistency and contradiction between the doctrines and effects, and leave no room for further doubt as to the true principles of the most successful practice.

REMARKS ON PARTIAL FRACTURE OF THE RADIUS.

By Gideon Algernon Mantell, LL.D., F.R.S., &c.

In the admirable lectures on surgery by Mr. Phillips, it is stated that a fracture may be incomplete, although some surgeons have denied the possibility of the occurrence, and, as conclusive of the fact, a sketch is given of a bone which had sustained such an injury.

Six cases of this kind have occurred in my practice during the last twenty-five years; and as the diagnosis is rather perplexing to a young practitioner, I am induced to offer a few remarks upon an accident which, although comparatively rare, every surgeon is liable to be consulted upon. The first case that came under my notice happened soon after I had left the hospitals, and I well remember how difficult it was to account for the symptoms, for I had been taught that partial transverse fracture was impossible. But I am convinced that a bone may be bent, and the convex portion of the curve be cracked, and yet the fracture be incomplete, and unattended with loss of continuity, as a tough twig may by bending be partially broken, and remain permanently curved, although not disunited. In the following case, which occurred but a short time since, the symptoms, peculiar to this injury, were well marked.

A fine, stout, ruddy boy, five years of age, son of B. Warren, Esq., of Clapham-park, was thrown from a donkey with considerable force; in falling he stretched out his left arm to save himself, and received a severe concussion on the ball of the left thumb. I saw him two hours after the accident; the palm of the hand was contused, but the principal injury was at the middle of the forearm, which was swollen and much bent, presenting the appearance of a transverse fracture of the radius and ulna. It was easy to ascertain that there was no dislocation, and that the ulna was uninjured; the head of the radius could be distinctly felt to rotate upon moving the wrist: but this bone was bent, the convexity of the curve being on the external aspect, and there was a corresponding hollow on the ulnar plane: there was no crepitus. Extension made no change in the appearance of the limb. The bone seemed to have been forcibly bent by the approximation of its distal and proximal extremities, occasioned