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ON

THE CAUSES OF DEATH

AFTER

AMPUTATION.

BY

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ASSISTANT-SURGEON AND SURGICAL REGISTRAR TO GUY'S HOSPITAL.

COMMUNICATED BY

JOHN BIRKETT, F.R.C.S.

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Investigations into the causes of death have ever been sources of much interest to the members of our profession; and although, from the want of definite facts, this subject has always been more or less wrapped in obscurity, still, in these days, when men are fully aware of the fallacies and dangers which follow upon a practice based upon mere opinions or impressions, gained by experience however extensive, the value of definite facts becomes daily greater; and in this statistical age we are apt to test all our knowledge and opinions by numbers. Where such a test can be applied, no one doubts its value, for figures have now a recognised and undoubted authority in our science, as in others, and wonderful indeed are the results which they have produced.

It is true that we occasionally meet with men who dispute their power when applied to such a science as ours, yet these same men trust to what they call their experience.

What, then, is experience? Is it an indefinite something which is non-communicable to others, and is not to be expressed, or is it a result more or less definite, arrived at through practical knowledge?

If the latter, as I believe true experience to be, surely it is capable of expression, and, in a measure, becomes statistical; and, however limited it may be, it can be represented by a number, from which to argue, or upon which to base an opinion.

Experience, to be of value, must be something definite; it must depend upon something more than mere impressions, although these may be the result of extensive observation.

Knowing, then, how impressions only lead men astray, it is our duty always to define our experience by recording observations, and then, by a fair analysis of cases of a similar character, to bring out our results; for it is true that such results, if fairly obtained, are of more practical value than any impressions, however gained. But to do this, much care is needful; for by classing together or by comparing dissimilar cases, a wrong result must ensue, and discredit, with erroneous conclusions, will necessarily follow.

With a view of gaining some distinct idea of the causes of death after amputation, I have collected from Guy's Hospital 300 cases of amputation, and have divided them into four classes. The ordinary division of traumatic amputations into primary and secondary I have not thought necessary to alter; but when we come to what are generally described as pathological amputations, it becomes evident that in the classing together of such cases as amputations for talipes, tumours, elephantiasis, deformity, and others of a like character, with those for diseases of the joints, a wrong result must ensue; and practically this is found to be the case.

I have, therefore, divided these cases into pathological amputations and amputations of expediency, choosing this term as more accurately expressing the reason for the operation; since limbs are removed for tumours, talipes,

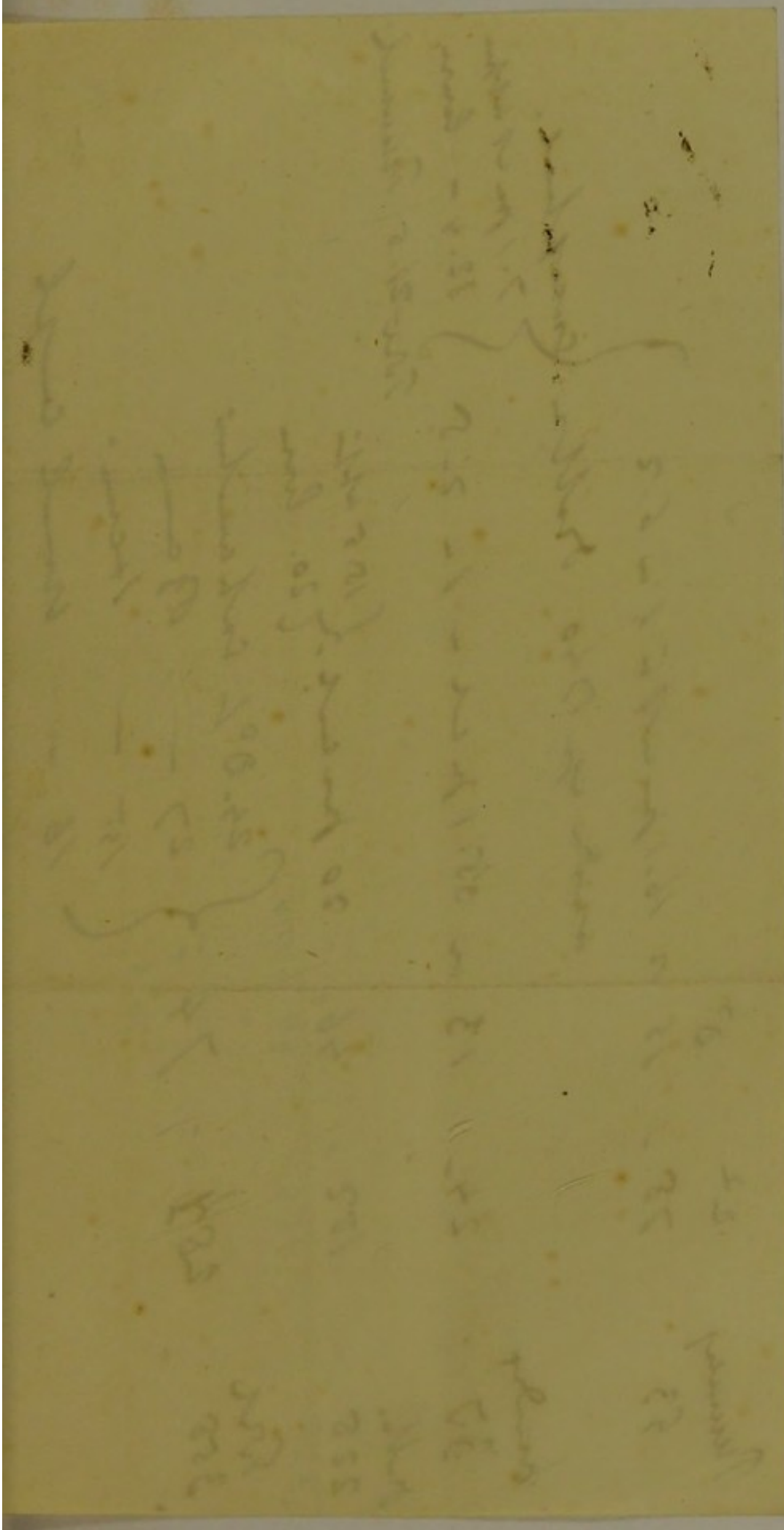
elephantiasis, and deformity more from expediency than necessity; and I would therefore suggest the use of such a term until a better is proposed.

The literature of this subject is very scanty indeed; with the exception of a valuable paper by Mr. James, published in the eighteenth volume of the 'Transactions of the Provincial Medical Association,' I am unable to point to any single memoir, in which the causes of death after amputation have been made a separate subject of investigation.

Mr. Alcock, in the twenty-third volume of the 'Medico-Chirurgical Transactions,' in a paper upon the Joints, made some few observations upon it, and promised at a future period to give the profession his views generally upon the causes of death after operations; but in this the Profession has been disappointed; and in presenting this short memoir to the consideration of my Surgical brethren, I trust that the imperfections of its pages will be counterbalanced by the importance and interest of the subject, and that others more competent to undertake such an investigation will follow my example, and in future fill up the deficiencies, which, I doubt not, are too numerous.

TABLE A.—*Of Amputations.*

	Pathological.			Amputations of Expediency.			Primary.			Secondary.			Total.			
	Cured.	Died.	Per Cent.	Cured.	Died.	Per Cent.	Cured.	Died.	Per Cent.	Cured.	Died.	Per Cent.	Total.	Cured.	Died.	Per Cent. and Average.
Thigh	82	18	18, or 1 case in 5·5	13	6	31·57, or 1 case in 3·16	8	12	60, or 1 case in 1·5	1	3	75, or 1 case in 1·3	143	104	39	27·27, or 1 case in 3·6.
Leg	36	3	7·7, or 1 case in 13	2	4	66·6, or 1 case in 1·5	9	15	62·5, or 1 case in 1·6	4	8	66·6, or 1 case in 1·5	81	51	30	37, or 1 case in 2·7.
Foot	5	...	...	...	...	...	1	...	...	...	...	...	6	6	...	...
Shoulder	...	...	...	1	...	...	2	...	...	...	...	...	3	3	...	...
Arm	10	...	...	3	...	...	10	3	23, or 1 case in 4·33	4	1	20, or 1 case in 5	31	27	4	12·9, or 1 case in 7·7.
Forearm	13	...	...	4	...	...	13	3	18·7, or 1 case in 5·3	3	...	...	36	33	3	8·3, or 1 case in 12.
Totals	146	21	12·57, or 1 case in 8	23	10	30·3, or 1 case in 3·3	43	33	43·4, or 1 case in 2·3	12	12	50, or 1 case in 2	300	224	76	25·3, or 1 case in 3·9.
	167			33			76			24						



Primary c2 D°

93 = 78 – 15 or 16.1 per cent [illegible] 1 in 6.2

under age [illegible] 40 [illegible]

Secondary

37 · 24 – 13 or 35.1 per cent – 1 in 2.8

[illegible]

7.1 per cent [illegible]

82.4 – – [illegible]

Total 21.5 [illegible]

[illegible]

228 – 182 – 46 – 20 per cent { 18.5 [illegible] / 20. [illegible]

195 159 36 . 18.4

Total

358 – 284 – 74 =

20.6

24.0% [illegible]

27 – [illegible]

15 – [illegible]

16 – [illegible]

26.1 — female

After primary comps. Exhaustion cause of Death 20 per cent
Traumatic Compl.[s] 40 —

— Secondary. Exhaustion . causes 38 per cent.
Secondary lesion 23 —
Ozaena . . . 15

Total Traumatic comps
28.5 for exhaustion .
26 — lesion .
7 — . Ozaena

Pollock . - Exhaustion 25 per cent .
Ozaena 35 —
Visual Compl. 15

Analysis of Table A.

Pathological amputations.—If we refer to the pathological amputations, as displayed in the first column, it will be seen that there are 167 cases, including

100	of the	thigh,	or about	60	per cent.
39	„	leg	„	23	„
5	„	foot	„	3	„
10	„	arm	„	6	„
13	„	forearm	„	8	„

Of these, 21 only were fatal, *i. e.*, 12·5 per cent., or about 1 case in 8; but as the fatality of amputations of the upper and lower extremity differs so widely, it is clearly incorrect to mix them together in statistical calculations, as by so doing we gain but an imperfect notion of the fatality of each.

By reference to the table it will be observed that out of the 100 cases of pathological amputations of the thigh, 18 were fatal, or 18 per cent., or 1 case in 5·5. Of the 39 cases of amputation of the leg, 3 only were fatal, or 7·7 per cent., or 1 in 13; and, taking pathological amputations of the thigh and leg together, 15 per cent. were fatal.

Amputations of the foot, arm, and forearm were all successful.

Amongst the 100 cases of amputations of the thigh, 89 are registered as being operated upon for chronic disease of the joint; and of these 13 proved fatal, or about 1 case in 7. (The fatality of excision of the knee-joint is, according to Butcher, at least 1 in 5.) Four were amputated for acute suppuration of the knee, and all died; 1 for gangrene of the leg, after ligature of the femoral artery for ruptured aneurism—also fatal. The remaining 6 all recovered; 4 being amputated for necrosed and carious bone,

1 after excision of the knee, and 1 for disease of the cellular membrane.[1]

Amputations of expediency.—If we pass on to the next column, containing the statistics of the amputations of expediency, a very different result will be manifested to that which we have just given. Of the whole number of 33 cases, 10 were fatal, or 30 per cent., or 1 in 3·3.

Amputations of the *thigh*, instead of yielding 18 per cent. of fatal cases, are there marked 31·57 per cent., or 1 in every 3·16 cases.

Amputations of the *leg*, instead of being 7·7 per cent. fatal, are registered as 66·6 per cent.

Amputations of the *lower extremity* as a whole are 40 per cent. fatal.

Those of the *arm* and *forearm* are all cases of recovery.

The difference in the fatality of the pathological amputations and of those of expediency, proves the error of associating them together in statistical or other calculations; and we now, by their separation, gain a more correct idea of the fatality of each.

The causes of death will be discussed as we proceed.

For what disease or cause amputated.—Twenty-nine of the 33 cases were amputated for simple or malignant tumours of bone, or elephantiasis; including 19 of the thigh, 6 of which were fatal; 3 of the leg, 2 of which were fatal; 1 of the shoulder, 2 of the arm, and 4 of the forearm, all of which recovered.

Two amputations for talipes were fatal.

One after a Chopart, and a second after a compound fracture for deformity, recovered.

Taking the amputations of the lower extremities for tumours alone, 36 per cent. were fatal; of the upper extremity all recovered.

[1] In the original two cases of amputation for conical stumps were included, but it has been thought desirable to omit them, and to add the next two cases from my book of amputations.

Traumatic amputations.—When we analyse the columns containing the statistics of the traumatic amputations, it will be seen that nearly 50 per cent. of the whole number proved fatal, and that there is but a slight difference between primary and secondary amputations; that difference, however, being in favour of the primary.

Taking amputations of the *thigh,* 60 per cent. of the primary were fatal, and 75 of the secondary; of the *leg,* 62·5 per cent. of the primary were fatal, and 66·66 per cent. of the secondary.

Taking both together, of the primary, 61 per cent. were fatal; of the secondary, 68 per cent.; the difference in favour of the primary being 7 per cent.

Amputations of the upper extremity in this division become more fatal, 7 cases proving fatal out of 39, or 18 per cent.

The causes will be alluded to in another page.

Analysis of Table A *as a whole.*

In considering amputations of the thigh as a whole, it will be seen that there are 143 cases; of these 39 were fatal, or 27·27 per cent., or 1 in 3·6. The order of fatality is as follows:

	Fatal.
1.—Pathological amputations . .	18· per cent., or 1 in 5·5
2.—Amputations of expediency .	31·5 „ or 1 in 3·16
3.—Primary amputations . .	60· „ or 1 in 1·5
4.—Secondary „ . .	75· „ or 1 in 1·33

Amputations of the *leg* as a whole were fatal to the extent of 37 per cent., or 1 case in 2·7; being 10 per cent. more fatal than amputations of the *thigh.* This difference depends upon the greater frequency of traumatic amputations of the leg; these, together with the amputations of expediency, being more fatal than those of the thigh. The reason why will be seen as we proceed.

The order of fatality is as follows:

	Fatal.
1.—Pathological amputations . .	7·7 per cent., or 1 in 13
2.—Primary amputations . .	62·5 ,, or 1 in 6
3.—Secondary amputations . .	66·66 ,, or 1 in 5
4.—Amputations of expediency .	66·66 ,, or 1 in 5

General Conclusions.

From a careful consideration of the whole, together and in detail, the following general conclusions may be drawn:

1. That in amputations of the extremities, taken altogether, 25 per cent. are fatal; 30 per cent. in the lower extremity and 10 in the upper.

2. That amputations, as a whole, are fatal in the following order: Secondary, 50 per cent.; primary, 43 per cent.; amputations of expediency, 30 per cent.; pathological, 12·5 per cent.

3. That in *pathological amputations* of the thigh, 18 per cent. are fatal, or 1 in 5·5; of the leg, 7·7 per cent. are fatal, or 1 in 13. Of the foot and upper extremity success generally follows.

4. That in *amputations of expediency* of the thigh, 31·5 per cent. are fatal, or 1 in 3·16; of the leg, 66·6 per cent. are fatal, or 1 in 1·5. Of the upper extremity fatal cases are exceptional.

5. That in *traumatic amputations* of the *lower* extremity 60 per cent. are fatal; of the *upper* 18 per cent.; and that traumatic amputations of the leg are at least as fatal as those of the thigh.

6. That *secondary amputations* are more fatal than primary.

7. That in amputations of the thigh for chronic disease of the knee-joint, 1 case only out of 7 proves fatal, or about 14·5 per cent. But for acute suppuration a fatal termination is the rule.

8. That in amputations of the *lower* extremity for tumours, 36 per cent. are fatal; after those of the *upper*, recovery may generally be expected.

	Pathological.			Amputations of Expediency.			Primary.					Secondary.				Total.				
	Thigh	Leg.	Total.	Thigh	Leg.	Total.	Thigh.	Leg.	Arm.	Forearm	Total.	Thigh	Leg.	Arm.	Total.	Thigh.	Leg.	Arm.	Forearm.	Total.
Exhaustion from shock of accident, operation, hæmorrhage, or all combined . . .	6, or 33 p. cent.	1, or 33·3	7, or 33·	1, or 16·6	...	1, or 10·	7, or 63·	2, or 15·	...	...	9, or 33·	1, or 33·3	6, or 75·	...	7, or 60·	15, or 40·	9, or 32·	...	...	24, or 33· per cent.
Pyæmia	8, or 44·	1, or 33·3	9, or 43·	3, or 50·	3, or 75·	6· or 60·	3, or 27·	7, or 54·	1, or 50·	1, or 50·	12, or 43·	1, or 33·3	1, or 12·5	1	3, or 25·	15, or 40·	12, or 42·8	2, or 75·	1, or 50·	30, or 42· „
Secondary hæmorrhage	1, or 5·5	1, or 33·3	2, or 9·5	...	...	...	1, or 9·	...	1, or 50·	...	2, or 7·	...	1, or 12·5	...	1, or 8·3	2, or 5·	2, or 7·	1, or 33·3	...	5, or 7· „
Hectic	1, or 5·5	...	1, or 4·7	...	...	...	...	...	...	...	...	1, or 33·3	...	...	1, or 8·3	2, or 5·	...	...	...	2, or 3· „
Cerebral complications	...	...	...	...	...	...	...	1, or 7·	...	1, or 50·	2, or 7·	...	...	...	...	...	1, or 3·5	...	1, or 15·	2, or 3· „
Thoracic complications	1, or 5·5	...	1, or 4·7	...	1, or 25·	1, or 10·	...	2, or 15·	...	...	2, or 7·	...	...	...	...	1, or 2·6	3, or 10·7	...	...	4, or 5·6 „
Abdominal complications	1, or 5·5	...	1, or 4·7	...	...	...	...	...	...	...	...	...	...	...	...	1, or 2·6	...	...	...	1, or 1·4 „
Renal complications	...	...	...	1, or 16·6	...	1, or 10·	...	1, or 7·	...	...	1, or 3·5	...	...	...	...	1, or 2·6	1, or 3·5	...	...	2, or 3· „
Carcinomatous infiltration	...	...	...	1, or 16·6	...	1, or 10·	...	...	...	...	...	...	...	...	...	1, or 2·6	...	...	...	1, or 1·4 „
Traumatic complications	...	...	...	...	...	...	1, or 8·3	2, or 13·3	1, or 33·3	1, or 33·3	5, or 15· *	...	...	...	...	1	2	1	1	5*
Total	18	3	21	6	4	10	12	15	3	3	33	3	8	1	12	39	30	4	3	76

* Excluded in calculation of per centages.

TABLE C.—*Of the different causes of death after amputation, showing their proportions per cent. in the different divisions.*

	Amputations of Thigh.					Amputations of Leg.					Arm.	Forearm.	Total.				
	Pathological.	Expediency.	Primary.	Secondary.	Total.	Pathological.	Expediency.	Primary	Secondary.	Total.	Total.	Total.	Pathological.	Expediency.	Primary.	Secondary.	Total.
Exhaustion from shock of injury, operation, hæmorrhage, or all combined	6·	5·	35·	25·	10·	2·5	...	8·	50·	11·	...	...	4·2	3·3	11·8	29·	8·
Pyæmia	8·	15·7	15·	25·	10·	2·5	50	32·	8·	14·8	6·4	2·7	5·4	18·	15·8	12·5	10·
Secondary hæmorrhage	1·	...	5·	...	1·4	2·5	...	...	8·	2·4	3·	...	1·4	...	2·6	4·	1·66
Hectic	1·	...	...	25·	1·4	...	...	...	...	...	...	...	·7	...	...	4·	·66
Cerebral complications	...	..	...	...	...	...	...	4·	...	1·2	...	2·7	...	...	2·6	...	·66
Thoracic complications	1·	...	...	...	·7	...	16·	8·	...	3·7	...	...	·7	3·3	2·6	...	1·33
Abdominal complications	1·	...	...	...	·7	...	...	...	...	...	...	...	·7	...	...	...	·33
Renal complications	...	5·	...	...	·7	...	...	4·	...	1·2	...	...	...	3·3	1·3	...	·66
Carcinomatous infiltration	...	5·	...	...	·7	...	...	...	...	...	...	...	...	3·3	...	...	·33
Traumatic complications	...	...	5·	...	·7	...	...	8·	...	2·4	3·	2·7	...	...	6·5	...	1·66
Total fatality	18·	31·5	60·	75·	27·2	7·7	66·6	62·5	66·6	37·	12·9	8·3	12·5	30·	43·	50·	25·3

Analysis of Tables B and C.

Causes of Death.

Pathological amputations.—We will now proceed to the more immediate subject of the causes of death after amputations; and reviewing the 21 cases of death after pathological amputations of the thigh and leg, we find that, analysing the 18 cases of fatal amputations of the thigh, 8, or 44 per cent., died from pyæmia upon the fifth, seventh, eighth, eighth, ninth, eleventh, twelfth, and forty-seventh days; 6, or 33 per cent., from exhaustion upon the fourth, eighth, eighth, eighth, twelfth, and nineteenth days respectively; 1 had secondary hæmorrhage upon the twelfth day, and died on the twenty-second, with diseased kidneys; 1 sank from diarrhœa upon the twenty-first day; 1 from diarrhœa and phthisis upon the thirtieth; 1 from hectic upon the twenty-second day.

Four of the 8 cases which died from pyæmia, were amputated for acute suppuration of the knee-joint, produced in 2 by the discharge of an abscess into the joint; in the remaining 4 amputation was performed for chronic disease of the joint. Out of the remaining 10 cases of death, 9 were amputations for chronic disease of the knee, and 1 for gangrene of the leg after ligature of the femoral artery for ruptured aneurism.

From the above, it would appear that amputation for acute suppuration of a joint is more frequently followed by pyæmia than amputations for chronic disease.

Of the 3 fatal cases of amputations of the leg, 1 died from secondary hæmorrhage upon the fifth day; 1 from exhaustion upon the twenty-fifth day; 1 from pyæmia upon the ninth day.

Reviewing these cases as a whole, and comparing Tables B and C together, we find that, out of the 21 examples of *fatal* pathological amputation of the lower extremity—

	Of fatal cases.	Of whole number.
Pyæmia was the cause of death in	43· per cent.,	and 6·4 per cent.
Exhaustion „ „	33· „	5· „
Secondary hæmorrhage „	9· „	1·4 „
Hectic, Abdominal and Thoracic complications „ each	4·5 „	·7 „

Amputations of expediency.—Under this heading we have but 10 deaths, the operations being less frequent than in the former division. 6 of these are of the thigh, and 4 of the leg.

Of the fatal thigh cases, 1 sank exhausted nine hours after the operation; 1 from diseased kidneys; 1 from infiltration of carcinoma; 3 from pyæmia, 1 upon the third day, and 2 from the secondary abscesses in the sixth and twelfth weeks. In 5 of these cases the limb was removed for tumours of the bone, and in 1 for elephantiasis.

Of the 4 fatal leg cases, 3 died from pyæmia upon the fifth, thirteenth, and thirteenth days respectively; 1 from pneumonia and bed-sore upon the thirtieth day. Two were cases of talipes, 1 of elephantiasis, 1 of tumour, and 1 associated with diseased bone.

In both the cases of elephantiasis, death followed from pyæmia, upon the third and fifth days.

Taking these amputations of expediency together, 30 per cent. were fatal; 18 per cent. from pyæmia, 3 from exhaustion, and the remaining 9 from visceral complications.

But as, by the table, it is seen that this operation, when performed upon the upper extremity, is generally followed by success, the average of the mortality of the lower becomes 40 per cent. The causes of death, and their proportion both to the fatal cases and to the whole number amputated, will be seen by the following table:

	Per centage of			Per centage of		
	Fatal cases.	Whole number.		Fatal cases.	Whole number.
Exhaustion proves fatal in	Thigh 16·6	.. 5·	Leg	—	.. —
Pyæmia „ „	50·	.. 15·7	„	75·	.. 50·
Visceral complications „	33·	.. 10·	„	25·	.. 16·

Conclusion. — Amputations of expediency of the leg are twice as fatal as those of the thigh; pyæmia, the most fatal cause of death, being 50 per cent. more fatal in amputations of the leg than of the thigh, and destroying half the cases of the former operated upon. Exhaustion and visceral complications caused death in the remainder.

Primary amputations.—Amongst these cases are 33 fatal examples; 12 being of the thigh, 15 of the leg, 3 of the arm, and 3 of the forearm.

Analysing the 12 cases of the thigh, 7 died from *exhaustion*, whether produced by the shock of the accident, of the operation, or from hæmorrhage, or all combined, upon the third or fourth days; 3 died from pyæmia upon the twenty-sixth, twenty-seventh, and twenty-eighth days, symptoms appearing upon the seventh, sixteenth, and twentieth days; 1 died from secondary hæmorrhage, which took place upon the third day, and proved fatal upon the eighth day; 1 from traumatic complications, as fractured ribs and ruptured spleen.

Amongst the 15 fatal cases of amputations of the leg, 2 sank from *exhaustion* upon the third day; 7, or 46 per cent. of fatal cases, from *pyæmia*—all dying about the twenty-fifth day, ten days after the appearance of the symptoms; 2 died from *pneumonic* complications—one from acute bronchitis on the twentieth day, and the second from pneumonia on the seventeenth day; 2 died from severe traumatic complications upon the third and eighth days; 1 from diseased kidneys upon the ninth day; 1 from delirium tremens upon the fifth day.

Analysing the fatal cases of amputation of the arm, 1 died from the traumatic complication of compound fractured thigh upon the fourth day; 1 did well till the thirteenth day, when sloughing appeared, followed upon the twenty-first by secondary hæmorrhage, and death on the twenty-second day; 1 died from pyæmia upon the thirtieth day, fourteen days after the appearance of the symptoms.

Proceeding to the fatal amputations of the forearm, 1 died from pyæmia upon the twenty-third day, symptoms appearing upon the fourteenth day; 1 from ruptured kidney upon the sixteenth day; 1 upon the fourth day from delirium tremens, associated with old arachnitis, the hemispheres being adherent at the median line.

Analysing the whole number of fatal primary amputations, amounting to 33 cases, 12, or 43 per cent., died from *pyæmia;* 9, or 32 per cent., from exhaustion; 5 died from visceral complications; 5 from traumatic complications; 2 from secondary hæmorrhage.

Taking out of our calculation the 5 cases which died from some traumatic complications, there remain 28 fatal examples, 43 per cent. of which proved fatal from *pyæmia;* 32 per cent. from *exhaustion;* 25 per cent. from visceral complications or secondary hæmorrhage.

On comparing these causes of death with the whole number of amputations, 16 per cent. died from pyæmia, 12 per cent. from exhaustion.

Primary amputations of the thigh prove for the most part fatal from exhaustion, produced by the accident, the operation, or both combined; two thirds of the cases dying from such a cause. The remaining third is caused by pyæmia.

In primary amputations of the leg, exhaustion has but a small influence in causing a fatal termination, but *pyæmia* becomes considerably more fatal, about half the fatal cases dying from such a cause. Visceral complications destroy the remainder.

In the primary amputations of the upper extremities, pyæmia is the chief cause of death, together with some accidental visceral complications.

Taking primary amputations of the *thigh* alone, 60 per cent. are fatal; *exhaustion* proving the fatal cause in 35 per cent., *pyæmia* in 15 per cent., and secondary hæmorrhage and traumatic complications in 5 per cent. each.

Taking primary amputations of the *leg*, 62 per cent. are fatal; *pyæmia* being the cause of death in 32 per cent.,

exhaustion, traumatic, thoracic, and visceral complications, in 8 per cent. each.

Comparing the two together, amputations of the thigh and leg are equally fatal (about 60 per cent.); but *pyæmia* is twice as fatal in amputations of the leg as of the thigh, and in these latter *exhaustion* is the chief cause of death.

Secondary amputations.—The 12 fatal examples include 3 of the thigh, 8 of the leg, and 1 of the arm.

Thigh.—One sank upon the sixth day from exhaustion; 1 upon the ninetieth from hectic and suppuration; 1 upon the twelfth from pyæmia, symptoms appearing upon the tenth.

Leg.—Four sank upon the fifth, fifth, ninth, and tenth days, in 1 diseased kidneys being found; 2 upon the eighth day, with gangrene of stump; 1 upon the second day, after secondary hæmorrhage; 1 upon the twentieth day, from *phlebitis.*

Arm.—One died upon the ninth day from *pyæmia,* symptoms appearing upon the fifth.

Analysing the whole number of cases, 7, or 60 per cent., sank after the operation from *exhaustion;* 3, or 25 per cent., from *pyæmia;* 1 died from secondary hæmorrhage; 1 from hectic.

Taking secondary amputations as a whole, a very different result to that obtained by an analysis of the primary may be educed from the consideration of the preceding facts.

Out of the 12 fatal cases, about 60 per cent. die from exhaustion; 25 per cent. from pyæmia; 15 per cent. from hectic and secondary hæmorrhage.

Exhaustion is here the chief cause of death, and not pyæmia, which sinks in proportion.

In secondary amputations of the *thigh,* 75 per cent. are fatal; exhaustion, pyæmia, and hectic being equally fatal causes.

In secondary amputations of the leg, 66 per cent. are fatal; 50 per cent., or half those operated upon, dying from

exhaustion; pyæmia and secondary hæmorrhage being fatal in only 8 per cent. each.

In *traumatic amputations of the upper extremity,* about 20 per cent. are fatal; pyæmia is the chief cause of death, one half dying from this cause; traumatic or some other accidental visceral complications prove fatal in the remainder.

Analysing the tables of the causes of death after amputation as a whole, and taking out of our calculations the cases which die from other injuries received at the time, we may fairly conclude that, amongst the 71 fatal cases—

42 per cent. die from pyæmia; 33 per cent. from exhaustion; 20 per cent. from visceral complications; 7 per cent. from secondary hæmorrhage. Hectic proves but a small cause of death, occurring in but 2 cases out of the 71, or not 3 per cent.

40 per cent. of all fatal amputations of the *thigh* die from *exhaustion,* and the same average from *pyæmia.*

32 per cent. of fatal amputations of the *leg* sink from *exhaustion,* and 42 per cent. from *pyæmia.* Secondary hæmorrhage, hectic, and visceral complications divide between them the other 30 per cent.

Comparing the same causes of death with the whole number of amputations, it will be seen that 25 per cent. are fatal, including 10 per cent. from *pyæmia,* 8 per cent. from *exhaustion,* 1·66 per cent. from secondary hæmorrhage, 1·66 per cent. from traumatic complications, and the remaining 5 per cent. from hectic and visceral complications.

Comparing *pyæmia* and *exhaustion* as causes of death after amputation generally, the following table will be of value, as showing the proportion they bear to one another:

In all *fatal* cases of

	Exhaustion is the cause in	Pyæmia is the cause in
Amputation of the extremities	.. 33· per cent.	.. 42· per cent.
Pathological amputation	.. 33· „	.. 43· „
Amputations of expediency	.. 10· „	.. 60· „
Primary amputation ..	.. 32· „	.. 43· „
Secondary „ ..	.. 60· „	.. 25· „

It will be observed, that in secondary amputations exhaustion is the most fatal cause, and in amputations of expediency the least fatal; and that in pathological and primary amputations the general average is maintained.

On the other hand, it will be seen that, regarding pyæmia as a cause of death, the above is exactly reversed; pyæmia being most fatal in the amputations of expediency, and the least so in secondary amputations. In pathological and primary amputations the general average is the same.

Comparing these fatal causes with the whole number of amputations, it will be seen in Table C that exhaustion is the cause of death in 8 per cent., and pyæmia in 10 per cent. That *exhaustion* is most fatal in secondary, and the least so in amputations of expediency, and that it destroys 12 per cent. of primary, and 4 per cent. of pathological amputations. *Pyæmia*, on the other hand, is most fatal in amputations of expediency, and the least so in secondary amputations.

Comparing the same causes, viz., pyæmia and exhaustion, as bearing upon the fatality of amputations of the *thigh* and *leg*, some interesting conclusions may be gathered from the following table:

	Pyæmia as a fatal cause.		Exhaustion as a fatal cause.	
	Thigh. Per cent.	*Leg.* Per cent	*Thigh.* Per cent.	*Leg.* Per cent.
In fatal pathological amputations	44· ..	33· ..	33· ..	33·
„ amputations of expediency	50· ..	75· ..	17· ..	—
„ primary amputations	27· ..	54· ..	58· ..	13·
„ secondary „	33· ..	12· ..	33· ..	75·
„ amputations generally	40· ..	42· ..	40· ..	32·

In pathological amputations of the thigh, *pyæmia* appears

to be a more frequent cause of death than in the same operation upon the leg; in amputations of expediency, it would appear that pyæmia is 25 per cent. a more frequent cause of death when applied to the leg than to the thigh; in primary amputations the difference is still more marked, for pyæmia is a cause of death in such operations upon the leg in the proportion of 54 per cent., and in the thigh but 27 per cent., or exactly twice as fatal.

In secondary amputations the reverse must be observed, for in the thigh, pyæmia is a cause in 33 per cent., in the leg, but 12 per cent.

From Table C similar conclusions may be drawn.

Touching the subject of *exhaustion* as a cause of death in cases of amputation of the thigh and leg, it bears exactly an opposite proportion to pyæmia; for when the numbers are high under exhaustion, they are low under pyæmia.

In *pathological amputations* they bear an equal average. In *amputations of expediency*, in which pyæmia is so fatal when applied to the leg, exhaustion is an unknown cause; and in the thigh it is the cause of death in but 17 per cent. of the fatal cases. In *primary amputations* of the thigh, exhaustion is the cause of death in 58 per cent.; of the leg in 13 per cent. only; being the reverse of pyæmia, which is 100 per cent. more fatal in amputations of the leg than of the thigh. In *secondary amputations*, again, exhaustion proves more fatal in the leg than in the thigh, in the proportion of 75 to 33 per cent.

Period of death from pyæmia after operation.—Amongst the 33 fatal examples of pyæmia, there are 15 cases following pathological amputations and amputations of expediency of the lower extremity; 12 of these died within fourteen days, the remaining 3 sinking from secondary abscesses in the second or third month. The symptoms made their appearance within a few days of the operation.

Among traumatic amputations there are 12 cases, 1 only of these dying upon the twelfth day, the remaining

11 cases sinking upon the twenty-fifth or twenty-seventh days.

In the upper extremity but 3 cases occurred, death taking place upon the ninth, twenty-third, and thirtieth days. The symptoms, as a rule, appeared from seven to fourteen days after the operation.

The difference in the duration of the disease called pyæmia, in the two classes of cases just mentioned, is worthy of observation; and although I am unable to explain why, after traumatic amputations, the patients sinking from pyæmia should live twice as long as in pathological amputations and those of expediency, the fact remains, and additional observations are required to solve the difficulty.

General Conclusions upon the Causes of Death in Amputations.

1. That 25 per cent. are fatal; 30 per cent. of the lower extremity, 10 per cent. of the upper.

2. That *pyæmia* is the cause of death in 42 per cent. of the fatal cases, and in 10 per cent. of the whole number amputated.

3. That exhaustion is the cause of death in 33 per cent. of the fatal cases, and in 8 per cent. of the whole number amputated.

4. That the following causes of death are fatal in the annexed proportions:

	Of fatal cases.	Of whole number.
Secondary hæmorrhage ..	7· per cent.,	or 1·66 per cent.
Thoracic complications ..	5·6 ,,	,, 1·33 ,,
Cerebral ,, ..	3· ,,	,, ·66 ,,
Abdominal ,, ..	1·4 ,,	,, ·33 ,,
Renal ,, ..	3· ,,	,, ·66 ,,
Hectic ,, ..	3· ,,	,, ·66 ,,
Traumatic ,, ..	7· ,,	,, 1·66 ,,

Pathological Amputations.

1. That pathological are by far the most successful amputations, only 12·5 per cent. proving fatal; such amputations of the upper extremity are generally followed by success, of the lower extremity 15 per cent. terminate fatally.

2. That *pyæmia* is the chief cause of death, proving fatal in 43 per cent. of the fatal cases, and in 5·4 per cent. of all pathological amputations; and when fatal, as a rule, it causes death within fourteen days of the operation.

3. That *exhaustion*, either from the shock of the accident or of the operation, from hæmorrhage, or all these causes combined, is the cause of death in 33 per cent. of the fatal cases, or 4 per cent. of all amputations.

4. That *secondary hæmorrhage* is the fatal cause in only 9 per cent. of the fatal cases, and in 1·4 per cent. of all amputations.

5. That hectic, abdominal and thoracic complications, act equally as causes of death in 13 per cent. of the fatal cases, and in 2 per cent. of all amputations.

Amputations of Expediency.

1. That 30 per cent. are fatal; but as amputations of the upper extremity are, as a rule, successful, the per centage of this operation upon the lower is much increased, 40 per cent. proving fatal.

2. That *pyæmia* is the chief cause of death, proving fatal in 60 per cent. of the fatal cases, and in 18 per cent. of all such amputations; and when fatal, as a rule, death takes place within 14 days of the operation.

3. That death from *exhaustion* occurs in but 10 per cent. of the fatal cases; and that some thoracic or renal complications, or carcinomatous infiltration, are fatal causes in the same proportion.

Primary Amputations.

1. That 43 per cent. are fatal; 60 per cent. of the lower extremity, and 30 per cent. of the upper.

2. That primary amputations are more successful than secondary.

3. That *pyæmia* is the cause of death in 43 per cent. of the fatal cases, and in 16 per cent. of the whole number; and that, when fatal, the symptoms appear, as a rule, between the seventh and fourteenth days after the operation, and cause death in the third or fourth week, and not during the first two weeks, as in pathological amputations and those of expediency.

4. That *exhaustion* is the cause of death in 32 per cent. of the fatal cases, and in 12 per cent. of the whole number.

5. That *traumatic complications* prove fatal in 15 per cent. of the fatal cases; and secondary hæmorrhage, cerebral or thoracic complications, in about 7 per cent. each; renal disease proving a cause of death in 3·5 per cent.

Secondary Amputations.

1. That 50 per cent. are fatal; 68 per cent. of the lower extremity, and 12·5 per cent. of the upper.

2. That secondary amputations are more fatal than primary by about 8 per cent.

3. That *exhaustion* is the chief cause of death, proving the cause in 60 per cent. of the fatal cases.

4. That *pyæmia* is the cause in 25 per cent. of the fatal cases; secondary hæmorrhage and hectic in the remaining 15 per cent.

Conclusions upon Pyæmia as a Cause of Death.

1. That it is the cause of death in 42 per cent. of all fatal cases of amputation, and in 10 per cent. of all amputations.

2. That it is the cause of death in the different forms of amputation in the following order: in 70 per cent. of all fatal amputations of expediency; in 43 per cent. of all fatal primary amputations; in 43 per cent. of all fatal pathological amputations; in 25 per cent. of all fatal secondary amputations; and that in amputations of expediency it is the most frequent cause, in secondary amputations the least.

3. That in amputations for acute suppuration of the knee-joint, whether the result of an abscess discharging into the joint or otherwise, pyæmia is a more frequent cause of death than in amputations for chronic disease.

4. That it is the general cause of death in amputations for talipes, elephantiasis, and tumours.

5. That in primary amputations, and in amputations of expediency of the leg, it is a more frequent cause of death than in the same operations upon the thigh.

6. That upon the whole, pyæmia appears to be a more frequent cause of death in amputations through limbs, the tissues of which are in a normal condition, and where a large surface of healthy bone is exposed.

7. That in pathological amputations, and in amputations of expediency, pyæmia, as a rule, proves fatal within fourteen days; but after traumatic amputations, the period of death is about the twenty-fifth or twenty-sixth day.

General Conclusions *upon Amputations of the Thigh.*

1. That 27 per cent. are fatal: of pathological amputations 18 per cent.; amputations of expediency 31 per cent.; primary amputations 60 per cent.; secondary amputations 75 per cent.

2. That in amputations of the thigh for chronic disease of the knee-joint, about 15 per cent. are fatal, or 1 case in 7.

3. That amputations of the thigh for acute suppuration

in the joint are generally fatal, and that pyæmia is the chief cause of death in these cases.

4. That exhaustion and pyæmia are causes of death in equal proportions, or in about 40 per cent. of the fatal cases, and in 10 per cent. of all amputations of the thigh.

5. That *exhaustion* is most fatal in primary amputations, and the least so in amputations of expediency.

6. That *pyæmia* is most fatal in amputations of expediency, and the least so in primary.

7. That primary amputations for the most part are fatal from exhaustion, 35 per cent. of the cases sinking from this cause; 15 per cent. from pyæmia; and from secondary hæmorrhage and traumatic complications 5 per cent. each.

8. That exhaustion, pyæmia, and hectic are equally fatal causes in secondary amputations, proving fatal in 25 per cent. each.

Amputations of the Leg.

1. That 37 per cent. are fatal: of pathological amputations 7·7 per cent.; amputations of expediency 66·6 per cent.; primary amputations 62·5 per cent.; secondary amputations 66·6 per cent.

2. That amputations of the leg are 10 per cent. more fatal than of the thigh; the amputations of expediency and traumatic amputations being more fatal, and the latter more frequent.

3. That amputations of expediency of the leg are generally fatal, being twice as fatal as those of the thigh. That pyæmia is the chief cause of death in 75 per cent. of the fatal cases, and in 50 per cent. of all such amputations.

4. That in primary amputations, pyæmia is the cause of death in half the fatal cases, or in 32 per cent. of all such operations; exhaustion and visceral complications about 8 per cent. each.

5. That, comparing primary amputations of the thigh and leg together, they are equally fatal; but that pyæmia is twice as fatal in amputations of the leg as in amputations of the thigh.

6. That half the cases of secondary amputation die from exhaustion; pyæmia and secondary hæmorrhage being fatal in 8 per cent. each.

7. That taking all amputations of the leg together, 42 per cent. of the fatal cases die from pyæmia, and 32 per cent. from exhaustion.

Amputations of the Upper Extremity.

1. That 10 per cent. are fatal.

2. That pathological amputations, and those of expediency are, as a rule, successful.

3. That about 20 per cent. of traumatic amputations are fatal; 22 per cent. of the arm, and 16 per cent. of forearm.

4. That one third of these fatal cases die from pyæmia, one third from some traumatic complication, and the remaining third from secondary hæmorrhage or visceral disease.