1	amputation of the middle and first finger	Healed.
1	„ index	„
1	resection of a finger	„
1	„ metatarsal bone	„
1	wound of hand	„
1	„ index	„
1	„ thumb	„
1	„ extremities of middle and ring fingers	„

(Truly a formidable series of cases to aid one in coming to a decision on the advantages of the method !)

1	compound fracture of the radius	Healed.
1	„ humerus	„
1	„ olecranon with opening of the elbow-joint	„

Further statistics are given by Hervey :—

1	compound fracture near the knee. Resection, afterwards amputation, exhaustion	Death.
1	amputation of thigh. High temperature and general unsatisfactory progress ; injection of quinine	„
1	amputation of first metatarsal bone	Healed.

Under M. Panas at Saint Louis :—

1	compound comminuted fracture of both bones of the leg. Gangrene, amputation, rigors	Death.
1	amputation of fore-arm for disease of wrist. Advanced phthisis; diarrhœa before operation	„
1	amputation of the thigh for white swelling ; eight days later	Sudden death.
1	amputation of crushed foot	Healed.
1	„ lower third of leg for frost bite. Ulceration, necrosis, re-amputation at seat of election	„
1	amputation (secondary) for crushed foot	„
1	amputation of thigh (limb torn off)	„

I give these statistics here, but I shall refer to them afterwards. Of course, in judging them, the infected state of the atmosphere must be taken into account.

In this method no attempt was made to obtain primary union, but in 1875, at the discussion on this method of dressing at the Academy,[1] M. Guérin stated that he then stitched up his wounds before applying his dressings, and that he frequently got union by first intention. He said also, that in the Hôtel-Dieu he had been having good results, but he does not give any statistics which can be used.

At that discussion, Pasteur and others pointed out that this was not an aseptic dressing, that bacteria and their spores were present in the cotton-wool when applied, and could be readily found in the discharge. Gosselin, who opened the discussion, mentioned similar facts, and he ended by saying that the dressing was good—(1) 'parce qu'il met à l'abri de l'inflammation suppurative trop intense ; (2) parce qu'il satisfait à cette indication par sa grande qualité d'être un pansement rare, qui maintient, sans interruption, l'occlusion, la protection, l'immobilité, la température uniforme, l'insensibilité, et la satisfaction morale, toutes conditions qui, si la santé antérieure n'est pas trop mauvaise, et si l'hygiène atmosphérique n'est pas trop défectueuse, conduisent à ce résultat très simple, et cependant bien grand, la formation rapide et sans étrave d'une membrane pyogénique ou granuleuse essentielle et promptement réparatrice.'

Of late Guérin has wet the deeper layers of the wool with carbolic lotion, and indeed in some cases uses a spray, for what reason it is difficult to imagine.

Verneuil[2] also speaks very highly of this dressing, and attributes its good results to the absolute immobility which is maintained, for by this means the granulation layer is preserved intact, and thus neither bacteria nor their products can enter the blood.

That it is not an aseptic method is evident from the whole description, and that it is not a very powerful antiseptic method is also evident. M. Verneuil, whose good results I have just alluded to, says of it : 'Quelle que soit l'épaisseur des couches entassées, le bandage, au bout de quelques jours, exhale un odeur désagréable. Le pus qui baigne la plaie est d'*une*

[1] *Bulletin de l'Académie de Médecine*, 1875. [2] *Amputations*, 1880.

extrême fétidité. Il renferme en quantité des vibrioniens et des bactéries, dont la putridité existe dans les profondeurs du pansement; et si les germes du dehors sont arrêtés au passage, ceux du dedans sont emprisonnés et forment à la blessure une atmosphère constante. Et qu'on ne dise pas que les matières putrides intérieures sont d'autre nature que les autres; car il résulte des expériences inédites de M. Poncet [1] que *le pus du bandage inoculé à des animaux a toutes les propriétés des matières septiques*.' He alludes to the following fact of extreme interest: 'Un élève de mon service, très bien portant du reste, était dans ce cas. Il était chargé du pansement d'un malade atteint d'écrasement des orteils, et qui était traité par l'ouate. *Chaque fois que l'élève renouvelait le bandage, il était pris de malaise et de diarrhée* presque subite, exactement comme lorsqu'il faisait la dissection ou l'autopsie d'un sujet putréfié.'

M. Ollier,[2] who soon saw the defects in this dressing, tried to remedy them by soaking the deeper layers of the cotton-wool in carbolic oil. He also applied a silicate bandage outside the cotton bandage. In August, 1872, M. Poncet gave the results of this modification. Of 10 patients operated on, 4 died—2 of septicæmia, and one of hospital gangrene.

In 1875, Ollier stated that he had got great benefit from this modification. He said that he had seldom seen a case of erysipelas; indeed in one winter, when it was very prevalent, only one case dressed in this way had erysipelas, while among the wounds treated otherwise he had 22 cases. He also thinks that when pyæmia appears under this dressing, it is of a mild form.

Substitution of various Gases for Air.

Other attempts were made to avoid the supposed evil effects of the gases of the air on wounds by *substituting other gases for them*. According to Rochard, these attempts were commenced in Clifton's laboratory while Humphry Davy was there. Perceval, then Ingenhousz, Beddoes, and John Ewart tried to utilise the analgesic properties of carbonic acid on ulcers. These attempts were renewed by Mojon in 1834, and by Simpson and Follin in 1856.

[1] *Lyon Méd.*, 1875.

[2] *Comptes-rendus*, Vol. LXXX.

Two years later Demarquay and Leconte [1] published a paper giving the results of an elaborate investigation on the effects of injecting various gases into serous cavities, or into the cellular tissue. The gases with which they experimented were air, nitrogen, hydrogen, oxygen, and carbonic acid. They came to the conclusion that none of these gases had any hurtful action when injected into the peritoneal cavity, or into the subcutaneous cellular tissue.

As to their effects on subcutaneous wounds, they state that subcutaneous tenotomy wounds into which *air* is blown every day organise much in the same manner and after the same lapse of time as simple tenotomies. *Oxygen* alone, when introduced daily, delays matters somewhat, but it never produces the abnormal vascular conditions caused by hydrogen. *Hydrogen* retards the healing for an indefinite time; indeed healing may be incomplete even after seven and a half months. *Carbonic acid* favours in a high degree the cicatrisation and organisation of the wounds, and healing is complete in a much shorter space of time than if the wound were left to itself.

From the result of these experiments they devised an apparatus for the purpose of keeping wounds in contact only with carbonic acid gas. In 1859 they say of the results: 'Many patients affected with gangrenous ulcers, with diphtheritic wounds or with wounds in an unhealthy state, having resisted the ordinary methods of treatment, have been treated by us during more than two years in the surgical department of the "Maison municipale de Santé," and have healed with a rapidity which was truly remarkable.' Similar experiments to those of Demarquay and Leconte were performed by Malgaigne in 1844 with air, and he also came to the conclusion that air does not impede the healing of wounds.

At the discussion on the influence of air on wounds in 1857 [2] Velpeau denied that air as such was deleterious, and said: 'Il y a longtemps que je me suis attaché à démontrer qu'il agit alors, non à la manière d'un irritant direct, *mais en raison des décompositions chimiques qu'il provoque dans les liquides*.

[1] *Comptes-rendus*, Vol. XLIX. See also *Essai de Pneumatologie Méd.* Paris, 1866.

[2] *Bulletin de l'Académie de Médecine*.

Ce sont ces liquides, et non pas l'air, qui, altérés, dénaturés, deviennent irritants pour les tissus qu'ils touchent.'

Open method.

While these discussions on the influence of the air, and these attempts to exclude the air from wounds, were going on in France, a method of treatment, apparently of the very opposite character, was being employed in Germany with better results. I refer to the *open method* of treatment.

Though Von Kern and Walther's methods were simply the use of water dressing, yet many of their wounds were left quite open. But the first to use the open method properly so called were BARTSCHER and VEZIN. The account of their method and work is published in the 'Deutsche Klinik' for 1856 by Dr. Vezin.

Thirty years before that time (about 1826) Dr. Bartscher asked Vezin to assist him at his first amputation of the thigh. After the operation, the dressings were applied, and the patient was left. During the night, bleeding having occurred, Vezin was called. He removed the dressing, and tried to find the bleeding point, but could not do so. He therefore concluded that the hæmorrhage was due to the pressure of the dressing, and accordingly he did not apply a new dressing, but simply brought the edges of the wound together by means of strips of plaster. Next morning this plaster had slipped, and the wound was quite open. No further dressing was applied, and the wound healed well.

They soon found that wounds healed perfectly well, if left to themselves, without any interference on the part of the surgeon; and ultimately they laid down the following as the best method:—Insert no stitches, apply no dressing, simply throw over the wound a piece of linen to exclude the flies, and use a cage to keep off the bed clothes. The pillow on which the stump lies is changed daily, but no attempt is made to cleanse the wound. During the first fourteen days little progress is made. The wound becomes covered with crusts, which crack and let the pus flow out. Healing is generally complete in eight weeks. Their cases were treated in a small hospital, each patient generally having a room to himself in the first instance.

Twenty-eight cases were treated in this way, with three deaths, consisting of—

14	amputations of the	thigh	No death.
6	„	leg	2 deaths. (6 and 36 days after).
4	„	upper-arm	1 death. (28 days).
2	„	fore-arm	No death.
2	„	great toe, metatarsal	„

The causes of death are not given.

In 1859 BUROW [1] published his method, which differed from the other in that the wound was only left open for half an hour or so till all oozing had ceased. The edges of the wound were then brought together by means of stitches and plasters, and a piece of lint was laid over it to keep out the flies. The stump swells up enormously during the first few days, and Burow thought that this was a good thing. He says that healing is much quicker by this method than by any other. In 1866 [2] he gives details of ninety-four amputations performed by himself or his pupils, with only three deaths. (Two further deaths are excluded, viz., one from tetanus which was present before the operation, and the other in which the patient lost a great deal of blood, and where Burow did not himself complete the after-treatment.)

These cases were:—

Amputation of	thigh (upper third)	9 cases (1 death).
„	„ (lower third)	12 cases (2 deaths).
„	leg	18 „
„	metatarsal and tarsal bones	7 „
„	close to shoulder	4 „
„	upper arm (upper third)	5 „
„	upper arm (middle)	7 „
„	„ (lower third)	7 „
„	fore-arm (upper third)	4 „
„	„ (lower third)	24 „

[1] *Deutsche Klinik*, 1859.

[2] *Deutsche Klinik*, No. 24.

In 1859 Burow discusses the causes of death in cases where dressings are applied. He says that the bandages prevent the swelling of the soft parts which was so very noticeable in his cases. Plugs of blood clot of a certain size form in the veins. When the bandage is removed, the limb swells, and these plugs become too small for the veins, and may be carried away, and cause emboli and pyæmia. Burow also refers to the bad practice of using unclean sponges, instruments, &c.

In a later paper[1] (1876) he speaks of his great success in excision of the mamma. He had operated on 53 cases during the last ten years, without a single death. In these instances, however, he washed out the wounds immediately before stitching them up with a mixture containing chiefly acetate of alumina, which we now know to be a powerful antiseptic (see p. 139). He also dressed suppurating wounds with pledgets of lint soaked in this solution and covered with gutta percha; and he himself speaks of the powerful effect of the solution in arresting putrefaction. These cases were, therefore, not treated by the open method, but by the addition of an antiseptic substance to the discharge, in many cases, no doubt, by complete exclusion of bacteria, i.e., on the Listerian or aseptic principle.

The chief advocate of the open method in England has been Dr. HUMPHREY, of Cambridge, whose great success at the Addenbrooke's hospital is well known. In a lecture on the treatment of wounds without dressings (1867),[2] he says: 'What is the great requisite—the sine quâ non—for the immediate union of wounds? Obviously, adaptation of the cut surface. Unless these are placed in apposition, they cannot easily unite. Hence the want of union is commonly proportionate to the want of apposition of the surfaces; and one great object in the treatment must be to secure as exact an apposition of the cut surfaces as possible, and to reduce to the minimum all substances, blood, dressings, ligatures, &c., that may intervene between them, and keep them apart. In the case of small and superficial wounds, there is little difficulty about this. Some simple method answers, and they heal at once.' In large wounds, the edges are brought together by means of sutures,

[1] *Archiv für Klin. Chir.* XX. [2] *British Medical Journal.*

and afterwards no application is employed with the exception of warm water dressing or poultices (rather opposed to the antiseptic element!), which are occasionally applied after a few days.

On the influence of air on wounds, he writes: 'But I am sometimes asked, is it not better to exclude the air? Is not the air a source of mischief? Is not the well-doing of subcutaneous wounds due in great measure to the exclusion of the air? To this I reply that it is certainly well to exclude air from the interior of the wound, where it keeps the surfaces apart, and promotes the decomposition of the fluids, and perhaps of the solids. On the surface of the wound, however, that is on the skin, it does not act as an irritant, and we should scarcely expect that it would. We have long been in the habit of leaving wounds of the face uncovered, and they usually heal remarkably well. Why should we not follow the same practice in other parts of the body?' Humphrey used acupressure instead of ligatures.

The open method was for a time pretty generally adopted in Germany and Russia, and to Krönlein's work on the subject I shall have to refer later. Of late, however, it has almost entirely given place to one or other mode of treatment with antiseptics.

Healing by Scabbing.

As we have already seen at p. 279, this is a nearer approach to aseptic treatment than the open method. As I have previously stated (p. 310), JOHN HUNTER made extensive use of this principle in the case of small wounds. He sometimes applied various powders to aid the formation of the crust.

Since Hunter's time numerous attempts have been made to carry out his principle of applying powders to aid the formation of crusts, but though they have answered very well in small wounds, they have not succeeded in large. Discharges collect beneath them, and tension is the result.

Among the substances employed in this way, have been various antiseptics, and of these may be mentioned NEUDÖRFER'S[1] powder. He uses salicylic acid, in the form of a powder,

[1] *Die Chirurgische Behandlung der Wunden*, 1877.

mixed with other substances, such as starch, zinc oxide, &c. He dusts the wound with the powder, and rubs it up with the fluids of the wound. Thus a mass is formed, which is again rubbed up with fresh powder till no more fluid comes; then over the whole some pure salicylic acid is applied, and a bandage. This crust is left on, and if on pressure on it some fluid exudes, more powder is applied. This is generally necessary five or six times during the progress of a case. This method is really only of use in small wounds. The objections to its use in large wounds are that the pain is great, the material is expensive, and there is very apt to be confinement of discharge. Neudörfer states that there is no bad smell in the cases treated in this way. Among them he has had no bad case of pyæmia, hospital gangrene or tetanus. He cannot say much about erysipelas. As a rule, in the cases which were attacked, it was generally some other part of the body which was affected.

Both James Moore and Astley Cooper tried to obtain crust formation by means of *charpie*, and the same sort of method was employed by Syme. The latter surgeon, after bringing together the edges of the wound, covered it with a piece of dry lint, which was left on for several days.

The *combination of a piece of lint with an antiseptic* was the method employed by Bennion of Oswestry. To quote Wm. Adams, who mentions this treatment in his publication in 1857,[1] Bennion's method in compound fracture was—

'1st. Immediate reduction; and in securing a good apposition of the fractured surfaces, he would frequently employ more force than many surgeons might think prudent, so that he very rarely had occasion to saw off any portion of bone.

'2nd. He cleared away all the blood from the wound, considering that it interfered with the reparative process, and brought the edges of the wound into apposition. He then covered the wound with a large bit of lint, saturated with compound tincture of benzoin, and bandaged the entire limb, firstly by itself, whilst extension was being kept up by an assistant, and then to a well-fitting splint adapted to the case; in the lower extremity he used a straight splint.

'3rd. He put the patient at once under the influence of

[1] *Subcutaneous Surgery*, 1857.

opium, upon which he placed great reliance, and kept up its action for a considerable time, according to the circumstances of the case.

'4th. He never disturbed the first dressing or bandage, unless urgent symptoms indicated the necessity for so doing. If such symptoms did not appear, he would allow the first dressing to remain a month.' It seems that Bennion had some very remarkable successes by this method.

Mr. Lister's first attempts to form a crust by means of *carbolic acid* have been already alluded to on p. 128.

Crust formation has been aided by the *drying of the discharges*. This occurred in Guyot's cases, though he did not aim at it. It was, however, the principle in the often misconstrued method of Bouisson,[1] the so-called 'ventilation of wounds.' Bouisson's method consisted in blowing air on to the surface of a wound by means of a caoutchouc bag. He generally directed the patient to do this himself. The 'ventilation' lasted a variable length of time, according to the extent of the surface and the quantity of fluid. A quarter of an hour generally sufficed for each *séance*, and this was repeated four or five times a day. The first crust which formed was rarely sufficiently thick or firm, but by-and-by the crust became of sufficient thickness, and when this was obtained, the ventilation was stopped. If the crust seemed to be confining the discharge and doing harm, it was softened and removed, and the process begun again.

Such was Bouisson's method of obtaining a crust, and as this method has been often quoted as shewing what a slight effect atmospheric dust exercises on a wound, it is interesting to note the advantages he claims for it. These advantages are: 1. A sedative action. Bouisson says that the pain diminishes so much that the patients often continue the ventilation for a long time. 2. Astringent action, so that the vessels are constricted and there is less tendency to inflammatory congestion. 3. Drying action, i.e. the formation of a crust. 4. This crust exercises a protective action, protecting the wound from the air, and also lessening the quantity of secretion. 5. Antiseptic action: from the evaporation and

[1] *Comptes-rendus*, t. 47, 1858.

concentration of the fluids, decomposition cannot occur. He says: 'Le contact de l'air et de ce liquide' (the discharges from a wound) 'sous l'influence de la chaleur animale détermine la formation des produits putrides sulfhydriques ou ammoniacaux, isolés ou combinés, et leur abondance contribue à faire naître des phénomènes typhiques ou ataxiques chez ceux qui se trouvent placés dans ces fâcheuses conditions. La ventilation des surfaces suppurantes a nécessairement pour effet de prévenir ou d'empêcher de pareils résultats, et l'on peut dire qu'à ce titre elle est autant un moyen d'hygiène générale dans les hôpitaux qu'un artifice local pour prévenir la resorption putride.'

In his conclusions, in which he lays stress on the points already mentioned, he says that wounds and ulcers so treated heal sooner and with fewer accidents, either primary or secondary, than wounds treated with dressings, or with any sort of medicament. He lays special stress on the avoidance of danger from a septic state of the pus. He recommends the use of this method in all small or medium sized wounds, ulcers, burns, &c.

The last mode of forming a crust which it will be necessary to mention is by *cauterisation*. This has been resorted to by various surgeons; first, I believe, by FAURE. An exhaustive paper on the subject was published in 1843 by BONNET.[1] The cauterisation may be done in various ways, either by caustics or by the actual cautery. Of caustics Bonnet finds that the Vienna paste or chloride of zinc alone are the best. The latter was extensively used by M. CANQUOIN and also by M. GENSOUL. Bonnet remarks that after its use he has never seen decomposition occur in the wound, or phlebitis and pyæmia. Bonnet preferred the actual cautery for various reasons. He attributed its good effects in the main to desiccation of the tissue, and he used the actual cautery more especially in wounds which had taken on a bad action.

Irrigation and the Water Bath.

These are very efficient antiseptic methods, and indeed, I believe, stand next in order of efficiency to strict aseptic measures, more especially when the water used is impregnated with an antiseptic.

[1] See also *Traité pratique de la Cautérisation, d'après l'enseignement clinique de A. Bonnet de Lyon.* Par R. Philipeaux, 1856.

Without entering into the older history, I may mention that OTIUS in 550 praises the use of cold water in recent injuries, and in some cases used more or less continuous irrigation. Again PALATIUS in the sixteenth century recommends the use of continuous irrigation with cold water, and speaks of having in this way obtained excellent results.

Two centuries later SMITH[1] in England (1725) and LAMORIER in France (1732) advocated its use. Lamorier, indeed, preferred prolonged water baths to irrigation. LOMBARD and PERCY used irrigation, and the former also employed water baths pretty extensively. It was not however till the publications of JOSSÉ and BÉRARD on irrigation in 1835, and of MAYOR on the water bath about 1836, that these methods were fully recognised.

During the further progress of this method, the various questions which have been agitated are, as we shall see, whether the irrigation or the water bath was the best; whether these ought to be continuous or intermittent; what the temperature of the water should be; and whether or not some antiseptic substance should be added to the water.

The first, as I have said, who in recent time called attention to this subject, was JOSSÉ; his work containing his views was edited by his son in 1835.[2] His reason for using irrigation was, that in this way a continuous and more perfect application of *cold* could be obtained. He used it in all the larger wounds, and in all inflammatory states. The apparatus which he employed was essentially the same as that now in use.

In the same year BERARD[3] (junior) published, quite independently, a paper on the use of cold water as an antiphlogistic. He also employed irrigation in order to obtain a constant diminution of temperature, which cannot be done, he thinks, by the application of cloths dipped in cold water, even though they are impregnated with substances which volatilise quickly. He

[1] *The Curiosities of Common Water*, 1723.
[2] *Mélanges de Chirurgie pratique, &c.*, 1835.
[3] *Mémoire sur l'emploi de l'eau froide comme antiphlogistique dans le traitement des maladies chirurgicales*, 1835.