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Plastic Apparatus in Surgery

by

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[Amer: Jour of Med: Science July 1842]

[Extracted from the American Journal of the Medical Sciences for July, 1872.]

PLASTIC APPARATUS IN SURGERY, WITH ESPECIAL REFERENCE TO THAT VARIETY MADE WITH PLASTER OF PARIS.

By SAMUEL B. St. JOHN, M.D., of New York.

(WITH TWO WOOD-CUTS.)

Fractures afford the widest field for the application of the dressing which it is the design of this paper to advocate, and hence no apology is needed for a few general remarks on the past and present treatment of this class of surgical injuries. The literature of the treatment of fractures gives more conflicting advice than that of any other department of surgery.

"While more has been written on the subject of fractures than on hernia, lithotomy, amputation, or trepanning, yet no two books correspond, no two authors agree, even on the general points of practice, and every surgeon sets a broken limb, as he writes his name, after a fashion of his own."—*Bell, Princip. of Surg.*, vol. i. pp. 490–1. Lond. 1815.

Even so late as 1855 the question of immediate reduction was discussed, the negative being upheld by distinguished London surgeons. That question is now, happily, beyond discussion, and the controversy is upon the manner in which, and means by which, the reduction shall be maintained. If the ability of the medical or surgical man successfully to cope with disease or accident is measured by the paucity of the methods of treatment or varieties of apparatus with which the indications are to be met (and it surely ought so to be measured), who of us could expect a favourable result to follow the treatment of a broken thigh or a Colles's fracture of the radius? And yet we do expect it. Our egotism leads us to think that, by our shrewdness or acuteness of observation, or mechanical dexterity, we (perhaps we only) have been able to find the pearl in this heap of rubbish, to select from this mass of various, and it may be conflicting, advice, that which alone secures the desired end. Much more delusive, and more mischievous perhaps, because harder to abandon, may be a conviction founded upon one's own observation or theories.

Nevertheless, I boldly assert my belief that no other apparatus is so successful for treatment of fractures generally as the so-called immovable apparatus, and no other variety of that apparatus so good as that made with plaster of Paris or gypsum. This assertion compromises me to the utmost, for it is the expression of a conviction founded upon extensive observation and personal experience, and sustained by theories, some of which are original, so far as my knowledge goes.

Some variety of splint which shall restore in a measure the lost continuity and support of a broken limb, seems a suggestion almost instinctive, and hardly allowing of discussion. From the time of Hippocrates to

1768, splints of some kind, generally short wooden strips, were bound around a fracture with this object in view. In 1768 Percival Pott published a paper (a Few General Remarks on Fractures and Dislocations. *Chir. Works*, vol. i. p. 221) in which he argued that the deformity, pain, and general distress attendant upon a fracture, were due *entirely* to irregular muscular action, and could be removed entirely by relaxing the muscles by position. His arguments were specious and forcibly conveyed, but they failed to secure the general adoption of his plan, for it was evident that he had lost sight of physical laws, which have so prominent a part in producing deformity and consequent pain; the distal end of a fractured limb falling by its own weight or failing to follow the proximal end, when that is moved either by accident or design. The muscular relaxation, too, it was seen, must be but partial, for the complete relaxation of a flexor group puts the extensors on the stretch, and *vice versâ*, so that a compromise, or semi-relaxation of both, is the best that can be had. Mr. Pott gives no statistics with his paper, showing results, but he says that this postural method "will not only succeed in all those cases in which the old method [by splints firmly applied] can ever be successful; but also in the majority of those in which it is not, nor, in the nature of things, can."

We notice also that he alludes to splints, which, according to Sir James Earle, he habitually used, and he insists upon having them extend over the joints above and below the fracture, and upon having them secured *loosely*, instead of firmly, as was then the general custom. It is easy to see that these long splints, though loosely bound on, would give more efficient support to a broken limb than the shorter ones then in vogue, be they bound never so tightly, so that Mr. Pott's *practice* was not such a revolution after all as at first sight it would seem. The probability is, that those cases which did well without any splints were those in which there was little or no tendency to displacement, and we confess to a disappointment in not having statistics of a number of cases of fracture of the femur giving the amount of shortening, where the treatment consisted simply in laying the limb upon a pillow in a flexed position.

Splints, therefore, still held their sway, and improvements were continually made in them as to lightness and adaptability to the affected limb. They were made of every conceivable material—straw, bundles of reeds or twigs, thin boards, sheet-iron, tin, wire, etc. Some of these were rudely moulded, to correspond to the contour of the limb, and the extension of this idea is to be found, at present, in all our instrument shops, in the shape of the elegantly carved and polished wooden splints, made rights and lefts like shoes, and warranted to fit any one who is patterned after the ideal Apollo of the maker. These splints, of course, required padding, elaborately arranged in order to make them support the fracture adequately, and to prevent too great pressure upon salient points, and the position of the pads was the prominent feature in the surgical instruction upon the treatment of fractures. These pads were continually slipping out of place,

which, of course, rendered them worse than useless until replaced—thus necessitating frequent reapplication of the whole apparatus, to the annoyance of the surgeon and discomfort of the patient.

Then came the era of an entirely new idea—new, as far as the surgeons of Christendom were concerned; but, like almost everything else worth knowing, it seems to have been known and practised by the heathen for centuries. This was to use some material which could be rendered temporarily flexible, or capable of being moulded so as to take the shape of any figure to which it was applied, and which, subsequently becoming inflexible and rigid, would preserve the imparted form. The distorted, deformed limb was then restored to its normal shape, and maintained there by an apparatus moulded over it—thus fitting a splint to the limb, and not, as had been too often done, fitting the limb to a particular splint. The originator of this idea is unknown, but whoever he may be, he made the most valuable contribution ever made to the treatment of fractures, and deserves the eternal gratitude of every sufferer from fractures, and of all surgeons who have fractures under their care, by enabling them to treat this class of injuries with more credit and less trouble to themselves, and more comfort to their patients.

The application of immovable apparatus to fractured limbs dates from a period too remote to be fixed with exactness. "The Greeks," says Pouqueville,[1] "used a kind of mastic to maintain fractures immovable, and the apparatus they left in place until the fracture united." Belloste in 1696[2] describes thus his application of an apparatus to a fracture of the femur with severe contusions: "As soon as he came into my hands, I made strong extension, reduced the fracture, and applied linen moistened with eggs beaten up with oil and vinegar . . . and placed the whole in a trough of pasteboard." This was allowed to remain for more than twenty days without being disturbed at all. A paper by Moscati[3] describes the application of an apparatus to a fracture of the humerus in 1739, which consisted in putting the limb in a kind of mould, "fabriqué sur elle même," constructing "so to say, a kind of box which embraced the humerus and extended over the scapula and clavicle." This he made out of "bandages, oakum pads, and linen compresses," and covered the whole plentifully with the whites of eggs to bind together the pieces. Cheselden[4] gives the description of an apparatus formed of several pieces of linen saturated with a mixture of white of eggs and starch, and says, "there is no other bandage equal to it in the treatment of fractures." Sédillot[5] describes an apparatus in use among the Arabs, made of leather, pierced with rows of holes through which were drawn sticks of polished wood to give stiffness,

[1] A. Bérard. Archiv Gén. de Méd., Nov. 1833, p. 389.
[2] Le Chirurgien d'Hôpital, p. 330.
[3] Mémoires de l'Academie de Chirurg., vol. iv.
[4] Anat., 7th ed., Lond. 1750.
[5] Gazette Méd. de Paris, 1838, p. 135.

and says that these sticks were withdrawn to allow pus to exude, showing that they recognized the great advantages of an apparatus for compound fractures which did not require removal in order to dress the wound, and he says that "the Arab surgeons make the pressure more agreeable and more uniform by wrapping the limbs in moss, and they make their apparatus immovable by covering it with a layer of clay, which in drying acquires the solidity of plaster." According to Paperi[1] the nomadic tribes in Tunis used plaster or mortar, such as was used for walls, in the treatment of fractures. Sir George Ballingall[2] says the natives of India used moulds of potter's clay, and relates an instance of a compound fracture of the leg in a little boy, for which he was preparing to amputate the leg, when the boy was carried off by his parents to a neighbouring potter, who made a casing of clay in which the leg eventually was saved. Nannoni[3] speaks of the apparatus formed of white of egg and flour, and states that it was in common use among the Italian surgeons, though he does not recommend it himself. Roche[4] saw it in constant use during the Spanish campaign, white of egg chiefly being used, and left on as a rule until the fracture, whether simple or compound, had healed.

We see, therefore, that the idea of fashioning a splint out of flexible materials moulded to fit the limb is of very ancient date. But, with this, as with almost all other valuable inventions, there seems to have been a time when it was forgotten—when he who revived and methodized it, and gave it a definite place in science, deserves equal credit with its author. The reviver was Baron Larrey, who had extensive opportunities for experiments and observation in the campaign in Russia, and who in 1830 published a monograph giving the "results of twenty years' experience with it." And, indeed, his experience would seem to have been even more extended than this, for he speaks of using it in the Rhenish campaign of 1792–4.[5] For important modifications we are indebted to Baron Seutin, M. Velpeau, and M. Mathiesen.

As the surest indication of the advance or regression of any new plan or invention lies in the criticisms of recognized authorities of succeeding generations, and as by them its fate is, in a measure, controlled, no apology is needed for presenting in this connection the opinion of leading surgeons of the past century, especially as by a comparison we may notice not only the progress of an invention, but the progress *in* an invention, or improvement in the invention itself, and in the method of its use.

Petit (following Belloste)[6] recommends the use of wetted pasteboard

[1] Lettera al Prof. Barzellotti, Siena, 1821.

[2] Outlines of Milit. Surg., ed. 1852, p. 358.

[3] Trattato della Malatt. Chir., Pisa, 1793.

[4] Nouveaux Élémens de Pathologie Méd. Chir., 5th ed., Paris, 1828.

[5] Sur le Traitement des Fractures des Os, 1832.

[6] Traité des Maladies des Os.

splints "because they can be moulded exactly to the limb, and because in hardening they acquire sufficient solidity to sustain all sorts of fractures, and especially those which seem the most difficult to retain."

In 1837 the Russian authorities were so convinced of the superior merits of the starch apparatus that they ordered it to be adopted by the army and navy surgeons. Malgaigne[1] disapproves of it, but partly in a negative way, saying that he cannot see its advantages. Sir William Fergusson[2] gives qualified approval while admitting his lack of experience with it, and says, "I cannot but admit, that a fracture may be admirably treated in this way also. It is difficult, however, to imagine that the practice will be either safe or efficacious in all instances. It seems to be little in vogue among British surgeons." Pirrie endorses heartily the starch bandage after the subsidence of swelling, saying that he has had no experience in its immediate application, though he is inclined to think favourably of it.[3] Syme[4] does not think the "new method of starch bandage" of any advantage, and refuses even to admit that it is of advantage to allow a patient to leave his bed "to be propped up in a chair," but he betrays by his language an ignorance of the method of application and of its results. Druitt[5] approves of it, but says it should never be applied until all chance of swelling is over. Velpeau, in 1841, was so much pleased with it that he treated all his patients, having fractures, in this way. Bérard[6] used it freely, and relates with great gusto a case of simple fracture of the fibula which he allowed to go about on crutches on the 3d day after the accident. Cheselden[7] also praises the immovable apparatus. In a thesis of Dr. Markam in 1840 he says, "the starch apparatus, in the treatment of nearly all kinds of fractures, is now generally adopted by the Parisian surgeons, Lisfranc and Jobert alone excepted." Marchetti[8] states that "at the hospital of Grosseto alone, in three years (1842–5) Seutin's starch apparatus has been applied with *invariable success* in 14 fractures of the femur, 10 of the leg, 2 of the humerus, 8 of the clavicle, and 10 of the forearm." Erichsen[9] says "by employing the starch apparatus in the way to be pointed out, I scarcely ever find it necessary to keep patients in bed with simple fractures of the thigh for more than six or seven days, or of the leg for more than three or four—thus saving much of the tediousness and danger." Hamilton[10] observes, "the cases to which this apparatus seems to be adapted are a

[1] Traité des Fractures et des Luxations, 1847, p. 263.
[2] Syst. Pract. Surg., p. 323.
[3] Princip. and Pract. of Surg., Lond. 1832.
[4] Princip. of Surg., Lond. 1842.
[5] Princip. of Surg., 1848.
[6] Archiv. Gén. de Méd., t. ii. 2me série.
[7] Operations in Surg. of M. Le Dran, trans. by Gataker, with remarks by Cheselden, 1768.
[8] Medical Statistics of the Tuscan Maremme.
[9] Science and Art of Surg., 2d ed., p. 182.
[10] Fractures and Dislocations, ed. 1860.

few examples of transverse or serrated fractures in which the bones have not become displaced, and in which little or no swelling is anticipated; and certain fractures which were originally more complicated, but in which a partial union, and the subsidence of the inflammation, have reduced them to a more simple condition; and especially is it adapted to cases of delayed union." The same author says, "I have even met with examples of compound fractures in which it has seemed proper to apply this dressing; but only when a sufficient time had elapsed to render it probable that there would be no sudden accession of swelling in the limb." The last author quoted has so far modified his views that, as he stated a few months ago, he is convinced that a fenestrated plaster of Paris splint is the best in which to treat nearly all compound fractures. "The objections to its use," Gross[1] remarks, "are altogether frivolous. The accumulated experience of the last twenty years is sufficient to convince any one of the safety and utility of this mode of dressing fractured limbs. It is not, of course, applicable to *all* cases, but there are few in which, in some stage of their progress, it will not be beneficial."

As we have already seen, the materials for making plastic apparatus have been very varied. The Greeks used "mastic" made of pounded shells or lime, white of egg, oil, and butter.[2] The Arabs used leather[3] and also plaster of Paris.[4] The natives of India employed clay,[5] the nomadic tribes of Tunis mortar. In the present century we find Larrey using a mixture of white of egg, camphorated alcohol, and extract of lead.[6] Velpeau, in 1830, used a mixture of ten whites of egg, ℥iv of lead-water, and ℥iij camphorated alcohol, but had previously used a glue of vinegar and rye flour. Seutin introduced starch, which was hailed by Velpeau as "une acquisition vraiment précieuse," but he (Velpeau) subsequently preferred dextrine "because the starch required heat, had to be applied with a brush or the hand, and did not readily soak into the bandages before their application." Also, because he thought it made a harder splint, and hardened more quickly. M. Chardon[7] recommends a mixture of white of egg, finely powdered alum, and lead extract, and in simple fractures also camphorated alcohol. In 1838, Lafargue de St. Emilion modified the starch apparatus by mixing with the starch powdered plaster of Paris, which possessed the quality of becoming "instantanement solidifiable." He gave this the name of the "gypso-amylacée apparatus," the proportions being equal parts of gypsum and starch. His contemporaries, however, seem not to have been impressed with the advantages of rapid consolidation, and it did not gain much favour. Pasteboard softened in water to

[1] Syst. of Surg., vol. i. p. 870. [2] Bérard, op. cit. [3] Eaton.
[4] Paperi, op. cit. [5] Sir Geo. Ballingall, op. cit. [6] Op. cit.
[7] De l'Etoupade d'Alun et de Blanc d'Œuf dans le Traitement des Fract., Bulletin Gén. de Thérap., Méd., et Chir., 1839, p. 355.

allow of moulding to the limb was used in the seventeenth century, and is spoken of by Belloste in 1696,[1] also by Bérard,[2] as being used by Assalini in Italy. Plaster of Paris began to assert its supremacy in 1852, and since that time only one other new material has been proposed, viz., silicate of soda, "soluble glass" or "water glass," which is recommended as being water-proof.

To sum up, then, regarding materials, we may say that leather, felt, pasteboard, and gutta percha—all of which may be softened in water—have always borne a high reputation. Liquid applications, to be applied with a brush or the hand upon a substratum of cloth, such as solutions of starch, glue, dextrine, or water-glass, have given a very brilliant series of results, and under this head may be classed that variety of the plaster of Paris splint made by soaking thick cloths in a plaster "cream" (made by mixing gypsum with water to the consistency of ordinary cream). The latest modification of this type of apparatus is made by using the dry plaster incorporated with the meshes of an ordinary bandage, as will be described subsequently.

With regard to the method of application of plastic apparatus generally, we may remark, that the earliest were made in a very clumsy manner by placing the limb in a box and pouring the plastic material around it, or by smearing it over the outside of the limb, as was done in those alluded to as being made of clay or mortar. The first advance was in wrapping the limb in some fabric, such as cloth or matting, which was smeared upon the outside. These methods secured a strong splint, it is true, if made thick enough, but exceedingly heavy and difficult to remove. A great improvement was made by soaking the cloths in the plastic material, made temporarily liquid by some menstruum—usually water. It was then found that equally strong splints could thus be made, which were much thinner and lighter than before, and the advantage thus gained by a combination of the fibre of the cloth with the resisting material led to a more intimate and uniform combination by making the splint out of roller bandage, saturated with the liquid starch, dextrine, or gypsum. An improvement, in my opinion, though not an essential modification is the use of the roller bandage having the plastic material rubbed in dry, as will be explained hereafter. In the mean time, a better idea of the methods of application will be obtained from the authors themselves.

Eaton, an English Consul at Bassora, in a treatise on the country of Syria,[3] describes the manner of application as he saw it among the Arabs:—

"A bad compound fracture of the leg from a falling field-piece, condemned to amputation by a European surgeon, was placed on oiled matting, the fracture reduced and plaster cream poured around it covering the posterior and lateral surfaces of the leg, foot, and part of the thigh. Pieces of hollow reed

[1] Op. cit.

[2] Op. cit.

[3] A Survey of the Turkish Empire, London, 1798, p. 218.

were arranged to carry the discharges from the wound. After this had hardened the whole circumference was covered, furrows being made to allow of moistening. Horizontal and vertical grooves were then made in order to remove it easily when necessary."

This patient recovered completely in four months. This method is now known as "plaster packing," or "half-packing," when the limb is only half encircled, and is now almost entirely out of use. A distinguished surgeon of New York tells me that he saw it in use in Halifax in 1868.

Korzeniewski[1] describes an apparatus consisting of eggs, soap, and alcohol spread on clean flax, strengthened with slender splints and covered again with the mixture until it was an inch thick. Pirogoff[2] used stiffeners of linen strips soaked in the solution, laid both lengthwise and crosswise, which were "not to be put where fenestræ were to be cut," the whole then to be smeared over with the mixture. Lawrence, of Brighton (succeeding Cheselden), used a method described in Chelius's System of Surgery,[3] in which he moulded his plastic materials (cloth saturated with white of egg and flour) over one side of the limb, and, when that was dry, trimmed the edges, and, re-applying it, moulded the other half, leaving about half an inch to allow of tightening when required. This he used until he thought all danger from swelling was over, and then he put over all a starch bandage making a solid casing. Larrey's apparatus was complicated; made of folded cloth, bundles of straw, pads of chaff and tow, compresses and a large piece of linen cut to fit the limb soaked in the white-of-egg mixture, the same being plentifully laid on outside. Seutin[4] at first used bundles of straw or strips of wood or iron as stiffeners, afterwards supplanting these by pieces of wetted pasteboard "*se moulant parfaitement sur toute la surface du membre fracturé*," and he simplified the apparatus of his predecessors by replacing the numerous pieces by simple linen rollers. He applied first a many-tailed bandage and placed (in fracture of the leg) alongside the tendo Achillis a small longitudinal splint, then a coating of starch, a second many-tailed bandage and another starch layer; two long side splints of wet pasteboard, reaching down so as to double under the sole of the foot, completed the apparatus. Seutin afterwards used the roller bandage soaked in starch solution. Lafargue,[5] thinking that the wet pasteboard stiffeners retarded the hardening, replaced them by iron wire. Seutin claims the idea of cutting up the splint so as to inspect the limb, and calls it his "appareil movo-amobile;" but Cheselden, in 1761,[6] recommends making the apparatus thin over the crest of the tibia "so as to facilitate cutting it up and tightening it when it becomes loose," so that he evidently practised it half a century before Seutin's time, and the successive steps would seem to be arranged as follows:—

[1] De Ossibus fractis tractatus, p. 496—quoted by Gürlt.
[2] Klinische Chirurg.
[3] Trans. by South., vol. i. p. 505.
[4] Mémoire sur le Bandage Amidonné.
[5] Gazette des Hôpitaux, 1839, p. 23.
[6] Op. cit.

To the Greeks and heathen of unknown ages belongs the origination of the idea. To Baron Larrey the reviving and methodizing of the practice. To M. Seutin the use of starch and the extension of the principle to the treatment of deformities, diseases of joints, varices, luxations, etc., and the revival of the practice of Cheselden of cutting the splint longitudinally, which was called by Velpeau "*une des plus précieuses qualités de cet appareil.*"[1]

I have thus far avoided giving the modern history of plaster of Paris, because, that being the material with which nearly all the cases in which I used the apparatus were treated and that used in nearly all the cases employed statistically, it requires especial mention.

This, which has now to claim our attention, has the advantage of hardening more rapidly than starch, dextrine, or white-of-egg, of making a stiffer splint, and of being easily cut off when desired if applied in the manner to be described. Dextrine is very hard to cut, and starch is very sticky and requires stiffeners usually to give the splint sufficient firmness.

Plaster of Paris, the hydrated sulphate of lime, for surgical use must have been slowly heated under 400° F. to drive off the water of crystallization and must be kept in a dry place moderately well secluded from the air. When mixed with water it combines with it and forms a hydrate, or "sets," becoming in a few minutes quite firm and hard. If the surgeon suspects that his plaster has become deteriorated from exposure to the air, he may restore it to its former condition by heating it for a short time at a temperature of about 350.°

The use of gypsum by the Arabs has already been alluded to. It was first introduced into Europe by Hendriksz, who used it successfully at the hospital of Gröningen. In 1816, Hubenthal,[2] apparently without knowing of Eaton's publication, applied it to a fracture of the forearm by the "packing" process, but he divided the case in halves by a string laid underneath the plaster, and pulled up through it just before it became hard, as moulds are made now by those who make plaster images. Its formal introduction to the surgical world, however, as a material for treating fractures dates from 1828, when experiments were instituted at Berlin by Klüge, Dieffenbach, and Keyl. In 1831, Wm. Beaumont introduced it into England, and it seems to have enjoyed moderate favour until 1854, when Pirogoff published a monograph[3] giving an account of its use in the Crimean campaign, which gave a fresh impulse to experiments with this material. Mathiesen in 1854, published a monograph[4] in which he

[1] Gazette Méd. de Paris, 1858, p. 764.

[2] Nouv. Manière de Traiter les Fract. Nouv. Journ. de Méd., tom. v. p. 210.

[3] Der Gypsklebeverband bei Einfachen und complicirten Knochenbrüchen und in seiner Anwendung beim Transport Verwundeter und auf dem Schlachtfelde.

[4] Du Bandage Plâtré et de son Application dans le Traitement des Fractures Liége, 1854.

advocated rubbing the dry gypsum into the meshes of a roller bandage, which is then to be rolled up, the whole to be moistened and applied like a dry bandage (*gypsverband*). This had the advantage of making an equally strong, though thinner and lighter splint, of being neater to apply, of applying itself to the limb more evenly and therefore of affording a more uniform compression, of being more susceptible of gradation of thickness to suit different limbs or different parts of the same limb, and finally, it could be more readily extended or pieced out should necessity arise.

In comparing a method of treatment of fractures with others, we should look at its results, its risks, its comfort to the patient, and its trouble to the surgeon, and perhaps, in the order given. For results I refer to the tables I have compiled, mainly from the records of Bellevue Hospital, taking all the cases I could find fully recorded, treated with this form of apparatus, being 187 cases of simple fracture and 26 cases of compound fracture. That there are risks attending it is not to be denied, but are there not risks with every form of apparatus? I can readily understand the unwillingness of some surgical instructors to advise this plan, though they believe in it themselves, knowing from observation, that this apparatus unskilfully applied and carelessly watched is productive of the most fearful mischief; but I am also convinced, that with skilful application and the use of the necessary precautions against accident, especially in the hands of one accustomed to the use of this form of apparatus, it is attended with less risks and gives better results than any other with which I am acquainted. Its comfort to the patient can hardly be considered under discussion, and the trouble to the surgeon is so much less than with other methods, that I was constantly in the habit of employing it when the case admitted of a doubt and I was pressed for time.

The *special advantages* may be enumerated as follows, but it should be remembered that we are here giving the advantages of gypsum splints, and that many of these belong to that variety in common with other moulded apparatus and not exclusively to it:—

- Perfect coaptation to irregularities of the limb, and as result of this—
  - Little tendency to displacement of splint. → Less trouble to surgeon.
  - Complete fixation of fragments. → Freedom of patient to go on crutches or otherwise.
  - Complete fixation of fragments. → Less irritation. Less extravasation of blood. Less swelling.
  - No injurious pressure over bony prominences. → Less liability of excoriation.
  - Uniform compression, giving— → Muscular rest. Diminution of spasm and removing one cause of displacement, preventing swelling and lessening it when it exists.

Rapidity of hardening; allowing the surgeon to hold the fragments in

position until the splint will hold them; simplicity of materials; extensive range of application; painlessness of application; lightness; porosity; elegance; cheapness; readiness of piecing out if necessary without removing it; ease and accuracy with which the strength of different parts may be varied; allowing wounds to be dressed without disturbing the fragments.

Little Tendency to Displacement of Splint.—In the majority of cases coming under my charge, the splints did not need adjusting for weeks at a time, and here we note a point made by Déroubaix,[1] that the irregularity of the contour of the limb, instead of being a hindrance, is a positive help and guarantee for immobility.

Freedom of Patient to go about.—The routine plan of treatment of a simple fracture of the leg at Bellevue Hospital was to put it up immediately, and get the patient up on crutches the next day. I hardly think that surgeons of the present day will agree with Malgaigne in saying that "for the patient to leave the bed is of no therapeutic utility, by it the surgeon only aims at pleasing the patient, at dazzling the eyes by a kind of 'tour de force' which is not wanting in originality."[2] I take it, that on this point, argument is unnecessary. Regarding this point in connection with fractures of the femur, he says:—

"As to these, which the best constructed apparatus, with the aid of confinement to bed, so rarely succeed in curing without shortening, to add to the already existing difficulties of the fracture, the dangerous chances of walking, without even having to anticipate the slightest advantages therefrom, is a temerity which happily it is not necessary to combat, for I know of no French surgeon who has attempted it."

I refer simply to my tables, where are recorded fifty cases of this very injury treated with an average result better than that obtained by any other method, and in which, singularly enough, the two worst results are in cases which for other injuries were confined to bed during the consolidation of the fracture.

Less Irritation, less Extravasation of Blood, and less Pain.—That these results should follow a plan which prevents the ragged fractured ends from tearing fresh nerves and bloodvessels with every motion of the body seems rational, to say the least. In the cases coming under my charge, the splints as a rule not only caused no pain of themselves, but greatly diminished that existing at the time of application.

Less Liability of Excoriation.—The only two cases of severe excoriation which I saw, were cases of fracture of the thigh, one of whom under my care was *non compos mentis*, and did not call my attention to the fact that the apparatus was hurting him until the excoriation had progressed considerably. The other was a man who was very tolerant of pain, and

[1] Mémoire au Congrès Méd. Belge, presenté Sept. 1836.
[2] Traité des Fracts. et des Luxations, 1847, p. 63.

said nothing, supposing that it was to be expected that the splint would cause some pain.

Giving Muscular Rest.—The roller bandage has had great reputation in all times in the treatment of fractures, as preventing muscular contractions, so painful to the patient and so productive of displacement of the fragments. "One overcomes entirely and at will the power of the muscles by the uniform and circular compression of a well-applied bandage," says Larrey;[1] and Velpeau[2] also gives a powerful argument upon the advantages of uniform compression. This apparatus is virtually a *snug bandage* which cannot get *out of place*, and painful jumping of the muscles after simple fracture was, in my cases, almost unknown.

Prevents Swelling.—Not only that which comes from blood extravasated from vessels ruptured by movement of the fragments, but that which results from inflammation, following the continued irritation, if motion be allowed.

Lessens Swelling which already exists, by the acknowledged action of steady, uniform compression.

Rapidity of Setting.—In this differing from all other forms of moulded apparatus, so that the surgeon can be sure of retaining in position whatever he can hold in place for fifteen minutes. Some of the cases given in the tables, especially cases of Pott's fracture complicated with backward dislocation, could not be kept in place by any mechanical device, even for a few minutes, but the quick solidification of a gypsum splint solved the problem at once.

Simplicity of Materials and Cheapness need no comment. *Extensive Range of Application* will be considered further on.

Painlessness of Application.—On several occasions, in applying leather splints to a sensitive fracture, the force required to mould the leather occasioned so much pain as to compel a resort to anæsthesia, while in applying plaster apparatus I never resorted to anæsthesia except to relax muscular contractions. Its *porosity* is such that it permits transudation of perspiration, so that I have frequently seen the outside of splints moist from that cause, and this quality is exceedingly valuable in announcing superficial excoriations (should they not be discovered prior to this by pain) by transmitting the serum. In the same way I have known a new opening of a compound fracture disclose itself.

Ease with which Wounds may be dressed.—The ease to the surgeon, and comfort to the patient with which a wound may be dressed through a trap in a gypsum splint, needs no urging to any who have seen it used.

The dressing, instead of being anticipated by the patient as a most painful though necessary process, is, in many cases, but a grateful irrigation of the wound, unattended by pain or even discomfort.

[1] Clin. Chirurg., 1829, tom. iii. p. 425.
Arch. Gén. de Méd., tom. iii. p. 210

I cannot coincide with Prof. Gross,[1] that "the *objections to its use* are altogether frivolous," knowing it to be powerful for evil, but I will express my conviction that those objections can be more easily overcome by a careful, judicious, watchful surgeon, than the objections to any other form of apparatus. They are as follow :—

Concealing Parts from View.—This is met by cutting the splint longitudinally so as to inspect the limb.

Constricting the Circulation.—This, the most weighty of all, is met in the same way, and we must remember that whoever bandages a limb, runs a risk of producing gangrene, but we do not, therefore, proscribe bandages. Gamgee[2] says of constriction and gangrene following the use of this apparatus :—

"In the numerous difficult cases which I have treated myself and seen others treat by this method, I never saw one of the accidents in question. I do not believe their occurrence possible in the hands of a skilful surgeon, except as one of those extremely rare, fortuitous occurrences which are apt to follow every operative procedure, and cannot be adduced as objections to a plan of treatment provided a sufficiency of well-established facts be adduced in its support."

Compression.—We have already seen the *benefits* of compression. It is charged that it prevents the formation of provisional callus, and delays the union.[3] The first I admit, the second I deny. Aside from the proven fact that some fractures unite with little or no callus, I noticed in cases under my observation, that there was a marked diminution in the amount of provisional callus, and frequently an apparent absence of it. With regard to union, as the tables will show, 51 cases of fracture of the tibia and fibula averaged 45 days in uniting; 27 of the tibia 42 days; 12 of the fibula 36 days; 12 of the humerus 37 days; 7 of the radius 31 days; 5 of the ulna 31 days; 19 Pott's fractures 39 days; 50 of the femur 44 days, etc. This is surely not long, and I have given tables showing the time of union in sixty-eight cases taken at random from the same records, where the limb was allowed to remain in a fracture-box, or loose splint, for at least one week, generally two or more; and attention is called to the fact that these cases compare most unfavourably with those treated from the beginning with moulded apparatus in just those fractures where the most motion is inevitable, viz., those of tibia and fibula, of tibia and of humerus. In experiments upon the lower animals, we find that if no splints are used, we get provisional callus; but using them we get none. It does not follow, however, that if we do part of nature's work she remains idle for a corresponding time. On the contrary, I believe that, finding the limb well supported, she goes immediately to work to make the permanent callus, and begins on the first week what is under other circumstances delayed till the fourth or fifth. On this point, Velpeau

[1] Op. cit.

[2] Surgical Researches, p. 169.

[3] Malgaigne, Gazette des Hôpitaux, No. 7, 1858.

says,[1] "we understand, then, that the accomplishment of this end (l'union) will be the easier and the more rapid, the more perfect the quietude in which the fractured limb is kept." Who does not see, then, that, other things being equal, an apparatus which is never, or but rarely, renewed after its first application, is that which presents the greatest chance to insure this immobility so favourable to the consolidation of the callus?

Excoriation from Pressure has already been discussed, and applies only to those cases where the apparatus is so applied as to maintain extension. Even here it is less liable to excoriate than other forms, because it takes hold of a broader surface.

Becoming displaced when Swelling subsides.—This is fully met by the longitudinal section and taking in the slack.

Softening of Apparatus, if it is wet from urine, etc., especially in children. This may be averted by protecting it with oiled silk, or by making the splint waterproof, in exposed places, by a coating of varnish.

Œdema through traps left for dressing wounds. This will seldom give any trouble if oakum is firmly bound on, or if it does, it shows that the whole splint is too tight and needs section.

Special skill required in applying and managing it. This is a valid objection, and was so acknowledged thirty years ago by Velpeau.[2]

"To reap the good effects of the compression of the immovable apparatus in cases of fracture, I cannot too frequently repeat that the bandage must be applied in a very methodical manner, because, though compression well exercised is a truly heroic means in such cases, I must also warn you that when employed by incompetent hands, it may become the cause of more or less serious accidents. Never forget it, it is a powerful resource, but it will not admit of mediocrity."

The longitudinal section of the apparatus is a great safeguard against constriction, and I would recommend it to every one not practised in the management of this form of splint. Even with this precaution, there is danger which only intelligent watchfulness can surely avert. Minor objections have been raised, that this method is uncleanly; soils the bed, the surgeon's clothes, etc. This is exactly in proportion to the surgeon's unskilfulness. With the plaster bandage especially, it is possible to put on a splint without soiling the bed linen or clothes, if only care be taken to squeeze the bandage tolerably dry. Dr. Pierson[3] says that this apparatus causes by its pressure a painful affection of the nerves and loss of power in the muscles, so that the disability of the limb is more lasting than after other treatment. Richter[4] states that it arrests perspiration and thus causes superficial excoriation. I can only say that neither of these points is sustained by my experience. I cannot forbear adducing, at the close of

[1] Considerations Pratiques sur le Traitement des Fractures, Leçons Orales, p. 628.

[2] Leçons Orales du Clin. Chirurg., Bruxelles, 1841.

[3] Remarks on Fractures, 1840, Boston.

[4] Abhandlungen aus dem Geb. der Pract. Med. und Chir., Berlin, 1832.

this list of objections, the following cases to which frequent allusions are made in the literature of this subject, extracted from this Journal for Feb. 1840, p. 460. They all, with one exception, occurred at one of the Parisian hospitals.

Case 1.—Colles' fracture; apparatus too tight; produced gangrene of the hand. Careful watching of the state of the circulation should have been able to anticipate this. In all the cases in which it has been applied at Bellevue Hospital, so far as I know, there has been only one case of gangrene, which was in an out-patient who failed to report for examination, as directed, coming back only after the mischief had been done.

Case 2.—Compound comminuted fracture of leg. Apparatus applied two and a half months after to enable him to go about on crutches, which he did, and one day he slipped and fell, breaking his leg again, for which the apparatus were removed, when some abscesses were found under the splint. He eventually made a good recovery.

Case 3.—Fracture of leg; good union in forty days, but some deformity. The apparatus was not applied *till all swelling had gone*, and there was no apparent reason why the splint should not have kept the bones in place if it was well made and the fracture was thoroughly reduced.

Case 4.—Fracture of radius and ulna, united with deformity. The splint became loose and cotton was tucked in at the ends to tighten it, a proceeding which left it still loose in the centre. It should have been cut longitudinally, a piece taken out, and reapplied with a bandage.

Case 5.—Fracture of tibia; delayed union; no apparent cause. Malgaigne thought this case illustrated the effects of compression in preventing the formation of provisional callus.

Case 6.—Fracture of patella. Starch bandage applied without any back splint to keep the pressure off from the vessels. Patient seen "a few times," and "suffering no pain;" was not seen again for two months. Results as might have been justly feared—gangrene.

The plaster bandage of Mathiesen has lately received a thorough trial at Bellevue Hospital, and with the most gratifying results. It combines the firmness and solidity of the plaster with the tenacity of the cotton fibre, thus securing a firm and tough splint with a minimum of plaster, and, by consequence, a minimum of weight, with the additional advantage of application in a form which enables the surgeon to secure the most accurate adaptation to the limb under treatment. The plaster bandage is prepared by rubbing the fine, dry plaster into the meshes of a cotton or flannel bandage, the coarser the texture the better (within limits), as it holds more plaster. I have used also bandages of canton-flannel, and coarse linen (towelling). The linen ones made the toughest and lightest splint, and ordinary flannel next best. Lately tulle has been used, and it is highly spoken of as making a lighter splint than any other material, but it is too weak to be snugly applied. Tarletan was the material used extensively by the Germans in the late Franco-German war, and they strengthened their splint by their wooden ribbons, pieces of which were worked in longitudinally. A fine film of plaster is then dusted over it and the bandage rolled up rather loosely. These bandages may be kept ready for use in

tin cans with tightly-fitting covers, or each bandage may be separately rolled up in tin-foil. In making a splint for a fractured leg, for example, the leg is first enveloped in a layer of cotton wadding, or, what I prefer, a single thickness of soft blanket. If cotton is used it is best to hold it in place by a roller bandage, loosely applied over it. Burggraeve[1] preferred to use a layer of cotton one and a half inches thick, and no dry bandage, which he claimed was so elastic that it followed the diminishing leg as swelling subsided. The blanket will need no bandage, but may be secured by a few stitches at intervals. The plaster bandages are then immersed in a basin of hot water to which about ℥ij of common salt have been added (the high temperature and the salt both contributing to the rapid setting of the plaster). In about three minutes they will be saturated, and are ready to be applied. Extension then being made upon the foot, and the bones adjusted, the plaster bandage is taken from the basin, squeezed firmly to get rid of the superfluous water, and applied after the fashion of an ordinary roller, from the base of the toes up to or beyond the knee, each successive turn being drawn snugly to its place, but not too tightly, especially if the bandages have never been washed, as they will in that event shrink a little in drying. Experiments show that the plaster in setting does not contract at all, so that there is no danger of ligation from that source. Three, or at most four, bandages should make a firm splint from the toes to the knee. In applying the roller, should the plaster, which it holds, seem to dry, the hand may be dipped in the basin and rubbed over the dry surface, and indeed, it contributes to the firmness and elegance of the splint to keep the hand constantly passing over the successive turns of the bandage, rubbing in the plaster and smoothing the surface. An elegant finish and, at the same time, some additional strength may be given by mixing about ℥ij of the plaster with so much water and smearing it smoothly over the surface. It is best not to apply a dry roller outside, until the splint hardens enough to hold the parts in position, as it retards the setting by preventing evaporation, but the limb should be carefully held by the surgeon for a few minutes, and then placed upon a rubber blanket until it becomes quite dry and hard, when a dry bandage may be applied, if desired, though it is not at all necessary.

Thus far, the application in an average case of simple fracture has been considered. Several details, which will at once enter the mind of the surgeon, must now be considered. First. How soon may the splint be applied? Let us see what was the practice of our predecessors. Larrey,[2] as a rule, applied it immediately, except where there was any considerable swelling, or where the muscular contractions were increased by the unavoidable handling of the limb. Velpeau[3] says "apply at once in all cases where there is not swelling, or where the soft parts are healthy, for swell-

[1] Nouv. Système de Pansements Inamovibles, Bruxelles, 1838, p. 20.

[2] Op. cit., quoted by Gürlt.

[3] Op. cit.

ing after fracture comes too soon for inflammation, and is mainly from extravasated blood, and an early reduction and complete retention of the fragments in place will prevent irritation, the initial step of inflammation, and prevent additional rupture of bloodvessels." Seutin (*op. cit.*) applied it at once, believing that it acted to prevent inflammation in still another way, the uniform compression of the bandage (according to his view) restricting the arterial, while it favoured the venous circulation. In a late article Volkmann[1] advocates immediate application, arguing that it tends to restrain traumatic reaction. For my own part, I believe that an intelligent surgeon, who can see his patient every day, and who employs the precautions alluded to, need not hesitate to apply the splint as soon as the patient comes into his hands. I speak advisedly in this, having repeatedly applied it while the patient was suffering from the shock of the accident, in injuries ranging from simple fracture of the fibula up to compound fracture of the femur, and in no case have I had occasion to regret doing so, but in all the cases the fixation of the irritating fragments has seemed to act as a prophylactic against swelling and general nervous irritation. In average simple fractures "constitutional symptoms" were almost unknown. These statements are supported by the cases given tabularly, where in eighty cases of simple fracture this splint was applied within twenty-four hours from the time of the injury, in many of them within two or three hours, and the fact that fourteen of these were from direct violence shows that cases were not selected which were less apt to be complicated by swelling. In twenty-six other cases the splint was put on within forty-eight hours, three being the result of direct violence.

Secondly. In what cases should cotton wadding be used as a lining, and in what cases blanket? A year ago I employed cotton where, from the contusion of the soft parts, great swelling might be anticipated; since I regarded it as a more elastic medium. At present I use blanket in every case, because it is more evenly distributed over the surface of the limb, and thus by giving more even support tends to prevent swelling, and also because by making an early section of the plaster casing it can be loosened a little should necessity arise.

Perhaps this reference to section of the apparatus will afford the most natural approach to an explanation of the manner in which it may be done, without hurting the patient or injuring the splint. This section may be most easily made about two hours after the application of the splint, as it then cuts like hard cheese. If, however, the section is delayed until the splint has become dry and hard, it may be softened in the track of the proposed section, by boiling water applied with a sponge for a few minutes. (Nitric acid is used by some for this same purpose, but it ruins the knife, sometimes goes through and blisters the skin, and does not make the section any easier.) A common shoemaker's knife, *kept sharp*, is the

[1] Berliner Klin. Wochenschrift, March 16, 1870.

best instrument to use in opening the splint, and the risk of cutting the patient may be reduced to a minimum by making two sections an inch apart, one on either side of the median line nearly through the plaster, and then raising the intervening piece at the top and completing the section by alternate nicks on either side. By thus removing a strip one inch wide a firm hold may be secured of the cut edge of the splint so as to spring it open to inspect the limb, and it also affords an opportunity of tightening the apparatus, should it have become loose by subsidence of swelling. Should the swelling, however, have gone down so much that it is necessary to remove a strip more than an inch wide in order to make it hug the limb, it will be better to remove the splints and make a new one, otherwise the tendency will be to roll the bones in toward the median line of the limb, in the case of the leg or forearm especially. I have tried various kinds of cutting pliers, Henry's, Seutin's, etc., and saws, also, but found none so serviceable as the knife. An instrument made by Leiter, of Vienna, a gentleman thoroughly versed in the management of gypsum apparatus assures me leaves nothing to be desired in this direction. Its mechanism is such that a tremendous leverage is obtained, so that when the lower blade is slipped between the splint and skin, the upper one cuts down upon it through the splint. The instrument has just been introduced into this country, and promises well, but I desire nothing better than a sharp knife.

In compound fractures the method of its application varies. If the opening through the soft parts is not large, and there is not much contusion or laceration, an apparatus like that for simple fracture may be applied, and a fenestra cut, through which to dress the wound. It must be made heavier and stronger than if the fracture were simple, but as the patient is to remain in bed with the limb supported for several days, if not weeks, this is not a disadvantage. In several such cases I found that five bandages were usually needed, and the splint was, in all cases of fracture of the leg, extended above the knee. The fenestra should be cut in accordance with the principles given in describing the longitudinal section of a splint for simple fracture. Some make a practice of leaving the piece covering the wound attached by one side like a trap-door, but in my opinion, it is neater to remove it entirely, as it enables the surgeon to trim the edges of the trap all around in a uniform manner, and moreover, the trap-door is apt to be in the way when the wound is being dressed. This method of procedure is, however, applicable only when the trap is to be of moderate size, of a breadth, perhaps, one-fourth of the circumference of the limb. The *length* of the trap is nearly immaterial, as it does not materially diminish the supporting power of the splint. When, from any cause, such as the extent of the external wound, or the suspicious look of the soft parts (and this applies equally to simple fractures with great contusion) it becomes necessary to have a large surface accessible to inspection without disturbing the fragments—a combination of the plaster bandage with blanket soaked in gypsum "cream" is to be used—and it was this

combination under the name of the "interrupted splint" which, during the past year, secured such brilliant and gratifying results at Bellevue Hospital in the treatment of bad compound fractures.

To apply this, the limb must be thoroughly inspected to find out what parts are least contused and least liable to become the seat of local trouble. It is only necessary to find a strip of sound tissue about two inches wide connecting the limb below the fracture with that above. If that can be found on the anterior surface of the leg or arm, so much the better, as the connecting band between the two parts of the splint will then be out of danger of being soiled by discharges, or of being wet when the wound is syringed out. A piece of ordinary blanket is then to be cut, about eight inches wide, and long enough to extend well above and below the joints on either side of the fracture. (In fracture of the leg it is usual to have this reach from the toes to the middle of the thigh.) The limb having been previously encased in blanket, as described for simple fracture, a plaster "cream" should be made, and the blanket previously cut out, immersed therein—or, which is preferable, the blanket may be laid upon a table and the mixture thoroughly rubbed in with the hand. It should then be folded upon itself twice so as to make a strip two inches wide, and laid along the part of the limb previously determined on. A plaster bandage should then be applied in the ordinary way below the point of fracture, binding the limb to the connecting piece and extending to as near the point of fracture as it is deemed safe to allow the limb to be concealed from view. Up to this point the limb has been supported by the hands of assistants, but no attempt made to reduce the fracture thoroughly. Now, the lower half of the apparatus being completed, an assistant, grasping it, makes strong extension (if necessary) and the bones are accurately adjusted. The upper end of the connecting band is then to be fastened to the limb above the fracture by turns of a plaster bandage. Thus an apparatus is made, fitting the limb accurately above and below the seat of injury, and having its two parts connected by a stiff bridge two inches wide—or, in other words, it is a plaster splint with an immense fenestra. In such an one which I made for a hopeless case of compound fracture of the leg, where the man refused amputation at first, the leg could be exposed from about three inches above the ankle-joint to two inches below the knee-joint, and the apposition of the bones which could be distinctly seen at the bottom of the wound, was perfectly maintained until the amputation two weeks later. In this case, owing to the oblique course of the crushing force (car-wheel), the only sound skin lay in a spiral line which I followed with the connecting band. If the connecting band is of necessity placed upon the depending side, it is of advantage to keep it away from the limb just opposite the wound by means of a thin blanket-pad placed under it; this pad to be removed after the splint has hardened, leaving a space through which a strip of oiled silk may be passed for the protection of the splint—the re-

mainder of the space to be stuffed with cotton or other material easily changed when soiled. Indeed the trap should be edged all around with oiled silk tucked under the edges, and cotton should be placed between the oiled silk and the skin to prevent the discharges from passing under the splint.

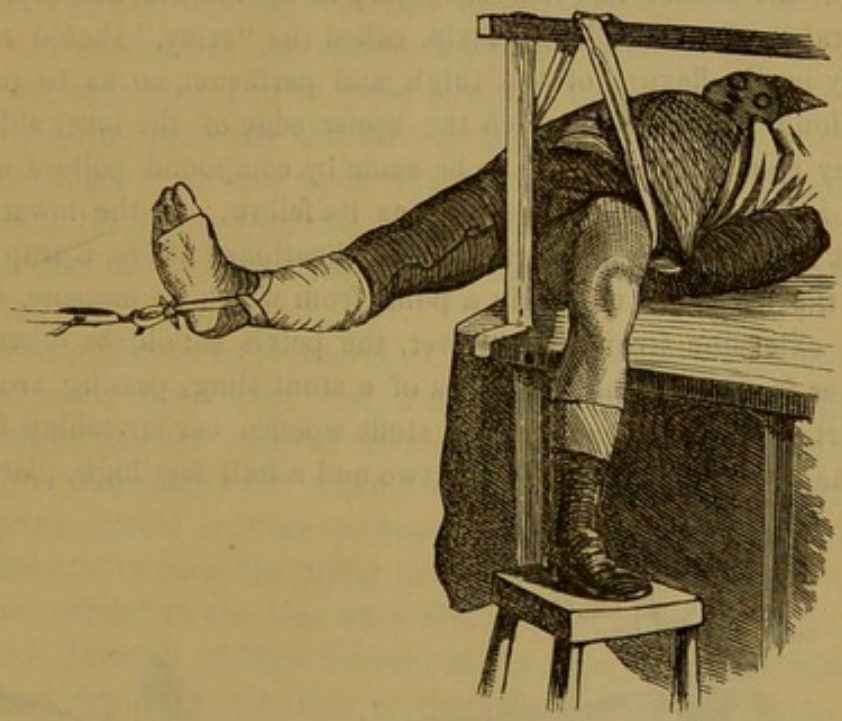
Another way which is very elegant, and which is of use in cases where the wound is not very large, is to cut, in a large piece of oiled silk, a hole a little larger than the wound, and then to fasten the edges of the hole to the skin around the wound by means of collodion. This collodion, being insoluble in the discharges, keeps the oiled silk so closely applied that the discharges are forced to find their way out through the hole in the silk, where they are received into a compress of oakum bound on. It will sometimes be found useful to paint the splint with a solution of gum shellac in alcohol (℥j to Oj) which gives it a water-proof finish. This, however, has two disadvantages; it prevents the transudation of perspiration, and it renders it somewhat difficult to enlarge the trap, should that be necessary, since it gives the surface a glazing which is extremely hard in itself and prevents the use of water to soften the splint in the track of the proposed section. In case the connecting band is found to be too weak, it may be at any time strengthened by additional strips of soaked blanket laid along it and secured above and below by turns of plaster bandage. In some cases where the connecting bridge was of necessity so narrow that I feared it would be too weak, I inclosed a stout piece of hoop-iron between the folds of the soaked blanket, the iron reaching about three inches above and below the proposed trap, the ends being imbedded in the more solid parts of the splint. This is also a useful plan to adopt when there is reason to fear that the trap might have to be enlarged and more strain brought to bear, consequently, upon the connecting band.

Special Fractures. *Fracture of the Femur.*—Perhaps in no other fractures have the merits of the gypsum apparatus been so conspicuous as in those of the femur, "it having triumphed here, not only by the brilliancy of the results, but by the comfort afforded the patient during convalescence." A simple fracture of the femur treated with any other form of apparatus compels confinement to bed for six weeks on the average, with the consequent lowering of vital status, discomfort to the patient, and trouble to friends and attendants; while with this the patient may be out of bed upon crutches the second or third day after the fracture, and is as comfortable and nearly as well able to wait upon himself during his whole convalescence, as is a man with simple fracture of the tibia in the fourth week of treatment under the old regime. And the results as regards shortening, time and strength of union, and subsequent usefulness of the limb, surpass statistically those of any other method of treatment, as a glance at the cases given further on will show. In the words of a surgeon whose name is identified with a different plan of treatment, "the statistics thus

far are better than those of any other method," and the refusal of a prominent teacher to recommend this method, is founded, as he himself acknowledged to me, on the belief that special experience is required to apply it properly rather than in any distrust of the method itself.

A description of the method of application is essential to the completeness of this paper, and I give it rather with that view than with the design of improving upon the admirable paper of my friend, Dr. Bryant.[1]

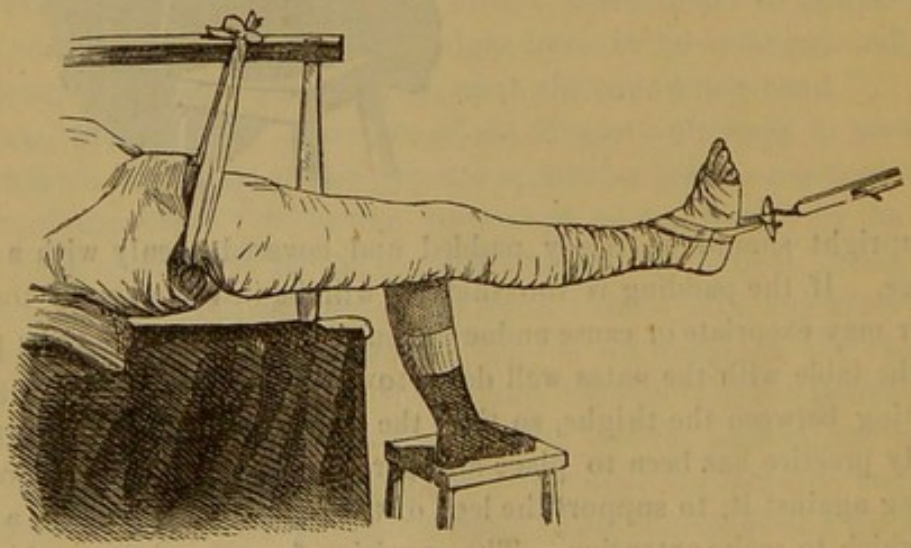
A table must be obtained and an upright bar about one inch in diameter secured to the middle of one end, so as to rise about two feet above the top of the table. In Bellevue Hospital an iron bar is kept which fastens on by clamps, but in private practice I have used with entire satisfaction, a wooden bar one and a half inch in diameter, put through a hole bored in the end of a common kitchen table and lashed to the braces below.



This upright should be thinly padded and covered evenly with a roller bandage. If the padding is too thick it will be in the way; if too thin the bar may excoriate or cause undue pressure. The patient is to be placed upon the table with the nates well down towards the edge, and the upright projecting between the thighs, so that the perineum rests lightly against it. My practice has been to place another table in line with the first and abutting against it, to support the legs of the patient and to afford a point from which to make extension. The provision for extension may be made in one of two ways, by traction upon a so-called Buck's extension apparatus, of adhesive plaster, which should be made with a very strong but narrow loop from malleolus to malleolus, so as to be in the way as little as possible, or, which is preferable, by a clove hitch around a stout plaster

[1] New York Med. Record, Sept. 15, 1871.

splint put on the day previous from the toes to the knee. A blanket previously spread upon the table should then be cut and drawn around the injured thigh so as to form a neat covering, and a strip eight inches wide should be extended around the pelvis. This should be drawn smooth and stitched as in a fracture of the leg. A strip of blanket one foot wide and four feet long (the relay), folded upon itself twice, so as to make a strip three inches wide, should be placed with its centre resting on the perineum and the ends brought obliquely upward and outward, the anterior passing over the crest of the ilium and the posterior over and above the tuberosity of the ischium. While the blanket is being adjusted, the patient may be etherized, and, as soon as fully relaxed, extension should be made, the scrotum (in the case of a man) having been carefully drawn upward and toward the sound side. The upright bar must be made to bear a little to one side of the median line to avoid injury to the urethra, and especial care must be taken that the blanket strip, called the "relay," should rest symmetrically in the flexure of the thigh and perineum, so as to present a groove along its center in which the upper edge of the inner side of the splint may rest. Extension is to be made by compound pulleys until the leg is by actual measurement as long as its fellow. If the lower half of the splint has been put on previously, as mentioned above, a trap may be cut over the malleolus to obtain a point from which to measure. Before applying extension strongly, however, the pelvis should be raised about four inches from the table by means of a stout sling, passing around the upper part of the pelvis and over a stout wooden bar stretching from the top of the upright to a stool, about two and a half feet high, placed upon



the table above the patient's head. Pillows should be placed under the head and shoulders to elevate them to a line with the pelvis. The bandages are now to be applied, piecing out the part already on and completing the splint as you pass upward. Pains must be taken to make a neat spica and not to allow the "relay" to become displaced. Small pieces of blanket soaked in plaster "cream" may often be used with advantage to strengthen

the anterior and antero-lateral portions of the upper part. Felt or pasteboard may also be used for this purpose, being worked in between the layers. About ten bandages will be needed in all, including those used in making the lower half. After the application is complete, the patient should be lowered to the table, but the extension should be kept up until the splint is quite hard. The projecting ends of blanket should then be cut off and the perineal edge trimmed with oiled silk to prevent injury by wetting, especially in children.

In Vienna, the upright used for counter-extension has a projection from its side, about six inches from the top of the table, on which the tip of the sacrum is made to rest, the body and upper lumbar region being supported by a frame about eight inches high which rests upon the table. In one of the cases given in the table (Case No. 23), Dr. Bryant used no upright for counter-extension, but made traction instead upon the "relay" in the perineum. This idea has been still further practicalized by Dr. Van Wagenen, at present connected with Bellevue Hospital, by passing counter-extending bands over the perineum and having brought them up one on each side, fastening them to a frame upon which the patient lies, which frame raises his body a few inches from the table, while his pelvis projects beyond its edge so that the hands of the surgeon can readily pass between that and the table.

In its application to *fractures of the tibia and fibula,* there is nothing especial to be said except that, these being the most common fractures, this method has here received the most thorough trial. Three good bandages (five yards long) will make a stout splint for most adult legs, unless the fracture should be near the knee, when four may be required, as it is then essential to carry the splint half way up the thigh, and it should in all cases extend to the toes when first applied to insure quiet of the leg muscles. In cases of high fracture of the tibia, it is often advantageous to make a circular amputation of the splint above the ankle after two weeks and begin passive motion of the ankle-joint. This is preferable to removing the leg temporarily from the splint. When there is great tendency to overriding, a good plan is to flex the leg upon the thigh sufficiently to enable the posterior surface of the thigh to act as a surface of counter-extension, the splint being carried above the knee. In Pott's fracture I have used with satisfaction, to produce inversion of the sole of the foot, a Dupuytren's splint applied outside the splint to give it shape while hardening, obviating the necessity of holding it, which may be tedious if the plaster is poor.

One case of Pott's fracture under my charge, complicated with backward dislocation of the foot, was so admirably maintained in position by a gypsum splint as to elicit the commendation of an avowed opponent of the system, who said he could not think of any other apparatus which would fulfil all the indications. When it is desirable to have the lightest possi-

ble splint, pasteboard, gutta-percha, or felt may be worked in between the successive layers of bandage, and they will be held so tightly as to be in no danger of slipping even if the splint be entirely removed and replaced. Two strips of felt and two plaster bandages thus disposed make an elegant, effective, and very light apparatus. The use of alum water (℥iv to Oij) in which to soak the bandages renders it possible to make a stiff splint out of two good plaster bandages, but in my hands they have proved brittle, not having elasticity enough to allow of their being sprung off (should there be occasion) without damaging them. Such splints, however, answer admirably after being cut down not only in front, but also posteriorly, leaving only two points of attachment of the two halves, one at the heel, the other at the top, so that the two halves were merely hinged together. The edges of these splints for the leg may be bound with adhesive plaster, so as to prevent their being broken by the surgeon's fingers in springing them open to inspect the leg, and this contributes much to the elegance of their appearance.

In a few cases of *fracture of the patella*, the plaster bandage has been used with remarkable success; in no case, so far as my knowledge goes, with a decidedly bad result. When the joint is tense with effusion, it cannot well be applied, but if there be only a moderate amount it may be used, and indeed, has been, with such a close union of the fragments that it was pronounced bony union. In these fractures, as there is usually little or no contusion, a roller bandage may be substituted for the blanket lining. Two firm compresses having been laid, one below the lower fragment, the other above the upper one, and secured by strips of adhesive plaster, the plaster bandage is then applied from the ankle up, making a figure of 8 around the knee and continuing the splint well up toward the groin. This should be applied while the patient sits on the edge of a table or chair to relax the extensors. Some place behind the popliteal space a light wooden splint, about four inches wide and a foot long, so that more tension may be used in drawing the fragments together by the figure of 8 turns without danger of constricting the limb. It will be seen that the summit of the knee may thus be left exposed for examination of the fracture, and it seemed, in two cases falling under my notice, that there was a decided tilting forwards of the fractured ends from the strong backward pressure of the bandage upon the other extremities of the fragments. This, it was claimed, could be counteracted by carrying additional turns of the bandage directly across the line of fracture, but it has the disadvantage of hiding the fracture completely from view. The number of cases is not, however, yet sufficiently large to enable one to cover up such a fracture with confident expectation of a good result. A compromise may be made by treating the fracture through a large fenestra cut in a stout plaster splint reaching from ankle to groin, which forms a posterior splint incapable of displacement, securing rest of the quadriceps extensor muscle, and

affording very convenient points of attachment for straps, strings, or adhesive strips, or whatever one may be using for the approximation of the fragments. In that plan of treatment, which consists in drawing the fragments together by strips of adhesive plaster crossing each other, this form of splint is especially useful, since traction can be made directly downward and the strips fastened to the front of the splint by a few turns of a dry roller, instead of passing downwards and *backwards* as in the ordinary posterior splints, and tilting the fragments forward as already alluded to. If, as some hold, the separation of the fragments is due mainly to effusion into the joint, the success already attained by the use of the bandage alone may be due to pressure stimulating absorption.

In simple *fracture of the ulna* it has in several instances proved itself to be all that could be desired. But as this is not a severe test of its powers it may be passed by with the remark that those who believe in interosseous pads for fracture of the forearm can mould a plaster splint before it hardens by indenting it firmly along the interosseous space, so as to make a prominent ridge when viewed from the inside. For convenience in allowing a coat sleeve to be worn, it is certainly admirable, while impatient but imprudent patients, who would rebel against wearing clumsy wooden splints, by way of precaution, after a fracture had united with tolerable firmness, will readily submit to a light and comfortable gypsum one.

In *Colles's fracture of the radius*, its advantages over other methods are not so evident. Still its record here is by no means a bad one. I succeeded in two cases in obtaining excellent results by using the gypsum bandage from the elbow to the wrist-joint, making the splint especially strong and thick at its lower edge, and holding the fracture reduced by pressure upon the splint until it was quite hard. In one case I used small pads upon the radial and ulnar borders of the lower part of the forearm, so that the splint could be more firmly applied without risk of arterial and venous obstruction. Of course the fingers and hand had to be bandaged with dry rollers. In fractures of the radius high up, the recorded cases are all in its favour. In fracture of both bones with tendency to shorten, counter-extension should be taken from the anterior surface of the upper arm, the forearm being flexed at a right angle and the splint extending about three inches above the elbow-joint.

In *fractures of the humerus* low down the forearm should be flexed at a right angle, and the splint applied from the wrist to the axilla. If there is much shortening, two methods are in use, one that just given, relying upon the weight of the splint for extension ; the other where the splint is extended over the shoulder, forming a shoulder-cap, by means of the spica, which closely hugs the axilla and takes its counter-extension from that part. It is claimed by some, that any effective counter-extension from the axilla would check circulation through the axillary vessels, but evidences of serious obstruction complicated none of the cases in which I applied it

although the upper edge of the splint was well imbedded in the axilla. The counter-extension was derived, it seems to me, mainly from the angle of the axillary border of the scapula with the long head of the triceps muscle, the scapula being tolerably well fixed by the spica and a body bandage.

In *fractures of the clavicle* it is not more successful than the usual treatment in Bellevue Hospital at present, by two strips of adhesive plaster, one around the arm and passing back, and the other under the point of the elbow and over the opposite shoulder. Applied in the ordinary way in which a roller bandage is used by some in this fracture, it is superior, inasmuch as it retains its place, the successive turns not sliding upon each other, but it is most serviceable as an auxiliary to the adhesive plaster strips, to distribute pressure, especially over the olecranon process of the ulna. I have twice seen œdema and commencing ulceration in the opening cut to avoid pressure over the tip of the olecranon process, the risk of which can be entirely avoided by the use of a little gypsum cap moulded over the elbow, a small pad (to be subsequently removed) making a depression which receives the olecranon.

So far as I have been able to learn, the plaster bandage has been applied only once in *fracture of the ribs*, and that was in the last case of this injury which came under my care during my hospital service. It occurred to me that it might possess two advantages over the adhesive plaster bandage, viz., less liability of slipping, and a certain amount of vertical stiffness not possessed by the adhesive plaster, the gypsum apparatus formed by successive turns of a three-inch roller sinking into the intercostal spaces and preventing the motion of the fragments under the spasmodic action of the bruised and irritated intercostal muscles, while it prevented the motion of the whole sterno-costal system equally well with the adhesive plaster bandage. The success of this single trial was all that could be desired, and the relief was more rapid and more complete than I have ever seen with the adhesive band.

In one case of *fracture of the inferior maxilla*, where a gypsum cap was made to fit the chin and was bound on with a four-tailed bandage, it seemed to me to be inferior to gutta-percha, being rather heavier and more clumsy.

In the manufacture of apparatus to fulfil certain indications after exsections, much opportunity is given for the exercise of mechanical ingenuity, and much independence of instrument-makers may be gained by the surgeon. Thus, in resections of the knee, elbow, or ankle, an apparatus may be moulded to the part previous to the operation, taken off and reapplied. This should be of the "interrupted" variety previously described, or, if desired, it may be "bracketed," that is, one where the upper and lower parts are connected by two or three iron brackets imbedded at either end in the solid plaster portions. An apparatus for use after an exsection

of the hip in a boy four years old has received such an unexpected amount of credit from surgeons who saw the case, and illustrates so well the variety of indications that may be met without expense of time, money, and patience at the instrument-makers, that I give it somewhat in detail.

The boy being placed, face downwards, upon a hard bed, and moderate extension being kept up on the leg operated on, a blanket was first thrown over his back and legs, as a lining for the apparatus. A blanket soaked in gypsum "cream" was then moulded over his back and legs, reaching down to the bed on either side, and between the legs. Strips of stout hoop-iron were laid upon this to serve as stiffeners or braces, and, additional pieces of soaked blanket being laid upon them, the edges of the first-mentioned piece were turned back over them and the blanket lining turned back over all. This hardened in a few minutes, was removed, trimmed, and a large opening cut to allow of defecation and of dressing the wound. Thus a mould of the posterior half of the body and legs was obtained, from the armpits down. The trough corresponding to the sound leg was turned up at its lower extremity to make a foot-piece, but the other was extended in a semicylindrical shape about six inches beyond the heel, and across its open extremity stretched a bent iron strip whose ends were imbedded in the plaster on either side. This served for the attachment of an India-rubber loop for keeping up extension by pulling upon a so-called Buck's extension apparatus applied to the leg. The little fellow, when bandaged into this was as portable as a log, and was taken out daily upon the balcony when the weather permitted. For more than two months he lay bound to this trough, and yet so evenly distributed was the pressure of his body that there was not even excoriation over bony prominences, although no padding of any kind was used; while another boy, in better condition, under observation at the same time, who had been subjected to the same operation and placed in a wire splint, developed two very troublesome bedsores in spite of all that I could do by padding and stuffing.

This immunity from danger in pressure upon a hard surface when the pressure is evenly distributed suggested to me the applicability of a gypsum apparatus in cases of threatened or actual bedsores, pressure being removed from the painful spot by cutting a hole or making a depression at that point. I have had only one opportunity of testing the practicability of this plan, and the result in that case was indecisive, the patient being at the time moribund. I am encouraged, however, by this case to repeat the experiment, and if successful it will be a cheap substitute for the air- or water-cushion, and not so readily displaced. In one case I applied a gypsum apparatus, at the instance of another surgeon, as a brace in incipient caries of the spine; but was not able to follow up the case.

Rest for inflamed or luxated joints is admirably secured by an apparatus like that for simple fracture, and any desired applications or inspection can be made through a large trap. Extension can be combined with rest upon the principles already given when treating of extension in fractures with shortening.

In contrivances to equalize pressure gypsum is invaluable. In a case of upward dislocation of the acromial end of the clavicle, a gypsum apparatus

extending from the wrist to the middle of the humerus (the arm being flexed at a right angle), fixed the forearm and distributed pressure over its whole ulnar side in such a way that an adhesive plaster strip carried under the forearm and over the clavicle held the bone in place for weeks without pain or inconvenience. The fact, that in this case, before the application of the gypsum apparatus, the pressure of the strap was so unbearable that it was necessary to take it off at the end of twenty-four hours, shows its utility.

A gypsum splint from the toes to the lower ring of a "Sayre's extension apparatus" for the knee-joint, proved very useful as a substitute for the adhesive plaster strips around the lower ring, and suggested itself to me by the continual slipping of the strips, necessitating reapplication of the whole apparatus. The pressure in these cases was evenly distributed over the dorsum of the foot, and caused no pain or excoriation. It will be seen that the extension was here maintained by pushing on the foot instead of pulling on the leg, as is done by the adhesive strips.

It has proved useful, also, as a temporary precautionary apparatus, applied to sound limbs upon which, for some reason (such as reduction of luxation, etc.), unusual strain was brought to bear. In case of a fracture of the humerus below the middle with luxation at the shoulder-joint, an apparatus of this kind might enable the reduction to be accomplished without waiting for the fracture to unite. In such cases, the fingers having been firmly bandaged, the splint should be applied very tightly, and after the reduction at once cut up longitudinally and loosened a little. Under this head of precautionary apparatus would come the splint mentioned in Case 10, further on, which was used where there was necrosis following a compound fracture, the sequestrum becoming loose before the fracture had united with sufficient solidity to allow of an operation unless the parts were thoroughly supported, and in which I removed through the trap a large sequestrum which, but for the splint, it would have been unsafe to meddle with, for several weeks.

I subjoin the statistics of 142 cases of simple fracture, mostly taken from the records of Bellevue Hospital, which were treated by the gypsum apparatus.

Of these 142 cases of simple fracture, there are 51 of the tibia and fibula (exclusive of Pott's), 27 of the tibia, 12 of the fibula, 12 of the humerus, 7 of the radius, 5 of the ulna, 19 Pott's fractures, 1 of the astragalus, 2 of the os calcis, 1 of the scapula, and 5 of the patella. The average time of union of the tibia and fibula was 45 days. 41 cases averaged only 36 days. The average time of union of the tibia was 42 days, and 22 of these averaged 38 days. Of the fibula, the average time was 36 days; of the humerus 37 days; of the radius 31 days; of the ulna 31 days; of Pott's fractures 39 days; of the ossa calcis 30 days.

Of the fractures of the tibia and fibula, 22 were put up in the plaster splint within the first 24 hours, generally within the first 12 hours; 4

were put up between 24 and 48 hours afterwards; 15 between 2 and 7 days, and 10 after that time. Of the fractures of the tibia alone, 11 were put up within 24 hours; 2 between 24 and 48 hours; 10 between 2 and 7 days, and 4 subsequently. Of fractures of the fibula alone, 4 were put up within 24 hours; 1 between 24 and 48 hours; 3 between 2 and 7 days, and 1 subsequently. Of fractures of the humerus, 7 within 24 hours; 1 between 24 and 48; 3 between 2 and 7 days, and 1 subsequently. Of fractures of the radius, 5 within 24 hours; 2 between 2 and 7 days. Of fractures of the ulna, 2 between 24 and 48 hours; 2 between 2 and 7 days, and 1 subsequently. Of Pott's fractures, 8 within 24 hours; 2 between 24 and 48 hours; 6 between 2 and 7 days, and 3 subsequently.

In all, 57 fractures were put up within 24 hours after the accident, and of these 8 occurred from direct violence, by which is meant heavy bodies falling upon them. 12 were put up between 24 and 48 hours, of which 1 was from direct violence; 45 between 2 and 7 days, of which 8 were from direct violence; 23 after the first week, of which only 1 was caused in that way.

The whole 142 cases average 40 days in uniting. Sixty of these cases were treated in wards with which the author was officially connected, as senior assistant and subsequently as house surgeon, and in a majority of these the apparatus was applied and the cases were watched by him personally, and care has been taken to verify the correctness of the hospital statistics of some of the most important cases by comparison with private records.

Not to confine my cases entirely to those treated with the gypsum splint, I have compiled the following cases, comprising, with those already given, all the simple fractures (exclusive of fractures of the femur) treated at Bellevue Hospital within three years, of which a full record is found on the books. The compilation is mainly with reference to the time of union.

First.—*Fractures treated with Leather, Felt, Pasteboard, or Gutta Percha Splints.*

24	cases	fracture of	tibia and fibula	averaged	44	days	in uniting.
15	"	"	tibia	"	37	"	"
9	"	"	fibula	"	43	"	"
27	"	"	humerus	"	39	"	"
18	"	"	radius	"	34	"	"
15	"	"	ulna	"	32	"	"
13	"	Pott's	fracture	"	37	"	"

Second.—*Cases treated for at least one week, generally two, with Fracture-Box, or other loose Splint.*

31	cases	fracture of	tibia and fibula	averaged	50	days	in uniting.
12	"	"	tibia	"	47	"	"
6	"	"	fibula	"	38	"	"
10	"	"	humerus	"	42	"	"
1	"	"	ulna	"	35	"	"
8	"	Pott's	fracture	"	45	"	"

Of the 1st class we have 121 cases, with an average time of union of 38½ days. Of the 2d class, 68 cases, with an average time of union of 47 days.

Table giving 50 *Cases of Fracture of the Femur treated with the Gypsum Apparatus.*

Name.	Age.	Date of fracture.	Point of fracture.	Am't of shortening.	Date of application of apparatus.	Date of removal of apparatus.	Am't of shortening after union.	Cause of fracture, and remarks.
				Inches.				
John McN	7	Jan. 13	Junction up'r & mid. thirds	....	Jan. 15	Feb. 23	None	
Pat. R.	37	" 7	Lower third.	½	" 9	" 23	None	
John W.	33	....	Below trochanter.	1½	Splint on	7 weeks	¼	Cart-wheel. Ether not used.
Ed. M.	3	....	Middle.	1	" "	45 days	¼	Kick of horse. Ether not used.
Frank P.	33	....	Lower third.	1½	" "	7 weeks	¼	Direct violence. Ether not used.
Ed. M.	14	....	Middle "	1½	" "	42 days	¼	Ether not used.
Pat. D.	19	Nov. 20	Upper "	1½	Nov. 28	Jan. 6	None	Direct violence. No ether.
James H.	45	Jan. 13	Middle.	1¾	Jan. 13	Mar. 1	¾	Fracture compound.
Adam B.	43	Dec. 15	"	1	Dec. 16	Jan. 21	½	Ether used.
David D.	63	Nov. 3	Cervix.	1½	Nov. 7	Dec. 19	¾	Ether used.
Peter O.	60	" 24	"	1½	" 29	Jan. 14	None	Ether used.
Charles S.	55	" 12	"	1½	" 16	" 7	¾	Ether used.
Thomas F.	16	Oct. 22	Middle.	1	Oct. 25	Dec. 5	½	Ether used. Direct violence.
Pat. M.	33	" 15	"	1½	" 16	Nov. 27	None	Ether used.
Wm. M.	4	July 19	"	¾	July 20	Aug. 25	¼	Ether not used. Walked on splint.
Pat. F.	28	" 24	Lower third.	....	" 25	Sept. 2	None	Ether not used.
Wm. S.	9	" 22	Middle.	....	" 23	Aug. 28	None	Ether not used. Direct violence.
Benj. R.	1½	Aug. 11	"	....	Aug. 12	Sept. 13	None	Ether not used. Direct violence.
John M.	10	Apr. 21	"	....	Apr. 28	June 2	⅜	Ether not used.
Ann H.	28	Mar. 2	"	1½	Mar. 3	May 14	⅜	Ether used. Fracture compound, and from direct violence.
Peter R.	29	Apr. 12	"	1¾	Apr. 14	" 26	None	Ether used.
Pat. M.	38	" 26	"	¾	May 6	June 24	None	Ether used.
Lewis G.	3½	May 21	Lower third.	....	" 21	" 29	½	Ether used. Patient walked on splint.
Conrad C.	13	June 6	Upper "	1	June 8	July 22	None	Ether used. Direct violence.
John W.	5	" 13	Middle.	1	" 14	" 20	None	Ether used. Direct violence.
John K.	32	July 14	Lower third.	1½	July 18	Aug. 30	½	Ether used. Wheel of truck.
James B.	35	" 27	Middle.	....	" 28	Sept. 8	¼	Ether used.
John M.	27	Oct. 5	Lower third.	....	Oct. 10	Dec. 1	⅜	Ether not used.
Nellie W.	4	Aug. 20	Middle.	1	Aug. 21	Sept. 20	½	Ether used.
James B.	35	July 27	"	....	July 28	" 15	..	Ether used.
James C.	32	Oct. 12	Lower third.	1	Oct. 13	Dec. 6	⅛	Fracture compound.
Frank A.	35	Aug. 7	" "	1	Aug. 16	Oct. 1	⅛	
Fred. B.	45	June 22	" "	....	June 24	July 31	..	Good union and position.
Mat. B.	4	Apr. 26	Upper "	....	Apr. 22	May 15	..	Good union and position.
David D.	59	May 16	Lower "	....	May 17	June 26	½	
Thomas L	6	Apr. 17	" "	1½	Apr. 19	" 1	None	Ether used. Fracture by direct violence. Splint cut longitud'y.
Mark W.	28	" 14	Upper "	2	" 15	" 6	None	Ether used.
John S.	..	Mar. 17	Lower "	2	Mar. 18	" 15	None	
Samuel L.	18	Nov. 11	Middle.	1	Nov. 13	Dec. 16		
John R.	55	Sept. 14	Cervix.	1	Sept. 18	Oct, 23		
Joseph C.	48	Aug. 22	"	....	Aug. 22	Sept. 20	1½	Patient in bed during treatment.
Mary B.	50	June 23	Cervix int. cap	1	June 25	Aug. 5		
John M.	32	Dec. 13	Upper third.	....	Dec. 14	Jan. 16	1	
George W.	5	Nov. 30	Middle.	....	" 1	July 6	1	
Wm. S.	43	May 28	"	....	.....	" 6	1	Patient in bed during treatment.
Fred. B.	45	June 22	Lower third.	Marked.	June 24	" 29		
John L.		Nov. 14	" "	....	Nov. 14	Dec. 29		
John McD.	7	Feb. 1	" "	½	Feb. 3	Apr. 10	None	
M. C.	..	Nov. 23	Middle.	Marked.	Nov. 25	Jan. 2	None	
John C.	58	Dec. 7	Lower third.	....	Dec. 7	" 24	¾	
Pat. C.	23	June 21	Middle.	2	June 24	Aug. 20	1½	Patient in bed during treatment.
Jas. D.	50	Apr. 23	Upper third.	1½	Apr. 26	June 23	None	

In analyzing the cases we find that the average shortening in all 50 cases is $\frac{1}{3}$ of an inch. The average shortening before treatment, so far as given, is $1\frac{1}{4}$ inch. The use of an anæsthetic does not seem to have essentially altered the result, for 38 cases where ether was used give an average shortening of $\frac{1}{3}$ inch. 35 of these, where patients went about freely on crutches, give average shortening $\frac{1}{4}$ inch. The average time of union in all 50 cases to time of leaving off splint is 44 days. 18 cases give no shortening, the average shortening of these 18 on admission was $1\frac{1}{3}$ inch. 16 cases under 18 years of age give $\frac{1}{6}$ inch shortening. 27 cases over 18 years give between $\frac{1}{3}$ and $\frac{1}{2}$ inch, and 21 of these average less than $\frac{1}{4}$ inch. In 23 cases the splint was applied within 24 hours; of these 6 were from direct violence, and 2 were compound. In 14 cases the splint was applied between 24 and 48 hours after the injury; of these 2 were from direct violence. In 8 cases the splint was applied between 2 and 7 days after, and in 3 cases after 7 days had elapsed.

	Average Shortening.	On Admission.
21 cases had femur broken in middle	$\frac{1}{4}$ inch.	$1\frac{1}{7}$
15 " " " junction of middle and lower third	$\frac{1}{5}$ "	1
7 cases had femur broken in junction of middle and upper third	$\frac{1}{20}$ "	$1\frac{1}{3}$
5 cases had femur broken at cervix	$\frac{1}{2}$ "	$1\frac{1}{4}$
1 case had femur broken below trochanter	$\frac{1}{4}$ "	$1\frac{1}{4}$

How do these statistics compare with those of other modern hospitals? Holthouse, in the last edition of Holmes' Surgery, says that at present, in London hospitals, shortening occurs after fracture of the femur in adults in 90 per cent. of the cases, and 50 per cent. in children. In these cases it is 25 per cent. in adults, and 50 per cent. in children. He gives 50 cases with an average shortening of $\frac{3}{4}$ of an inch. He recommends the plastic apparatus for infants, and for adults after the *first six weeks*. A paper by Dr. Gurdon Buck, of this city, in 1861, gives 20 cases, 17 of which had from no shortening up to $1\frac{1}{4}$ inch; average, $\frac{1}{2}$ inch; only 1 adult without shortening, and 3 children. In a number of cases collected by Dr. Shrady from the Records of the New York Hospital in 1859, out of 74 cases 19 had no shortening; 55 had $\frac{3}{4}$ inch. Of the 19, 13 were over 12 years old. Average shortening of the 11 under 12 years of age was $\frac{1}{2}$ inch. In 27 cases reported in *New York Journal of Medicine*, 1858, by Mr. J. Campbell, the average time of union was 45 days.

In every point, then, are the statistics of cases of fracture of the femur treated by this method superior to those of any other method. It seems to me idle to say that the patient runs too many risks of falling, etc., if he is allowed to go about on crutches. Surely he runs risks if confined to a close room, or the foul air of a hospital ward, when he might be breathing the pure air outside. The difference seems to be that if he falls and re-fractures his thigh it is chargeable to the stupidity of his surgeon; if he dies from pneumonia, empyema, or an enormous bedsore over his sacrum, it is a "visitation of Providence."

Table giving Statistics of 26 *Cases of Compound Fracture treated with Gypsum Splint.*

No. of case.	Name.	Age.	Date of fracture.	Bone and Point.	Date of application of apparatus.	Date of removal of apparatus.	Result.	Remarks.
1	Jno. T.	22	Oct. 18	Tibia, middle	Oct. 19	Nov. 27	Good union and position	Fractured by direct violence.
2	A. S.	20	Aug. 31	Tibia and fibula, middle	Aug. 31	Oct. 6	Some union	Complicated by temporary œdema and erysipelas; good union two months after.
3	Chas. A.	26	Aug. 19	Olecranon process	Aug. 19	Sept. 15	Good union	Some stiffness at elbow which disappeared afterwards.
4	Mary N.	35	Apr. 16	Tibia and fibula, lower third	April 27	.....	" "	Old fracture with necrosis.
5	David O.	40	Jan. 29	Tibia and fibula, middle	Jan. 29	Sept. 22	" "	Emphysematous and great extravasation of blood.
6	Jno. R.	40	Sept. 26	Pott's	Sept. 26	Dec. 20	" "	Fractured by direct violence.
7	Peter G.	39	Nov. 17	Tibia and fibula, upper third	Nov. 18	Jan. 20	Tolerable union	See detailed record. Fractured by direct violence.
8	Wm. W.	15	July 2	Tibia and fibula, lower third	July 2	Oct. 7	Good union	" " " " "
9	Wm. F.	12	June 22	Radius and ulna, middle	June 22	Aug. 5	" "	Fractured by direct violence—struck by a piece of wood; wound small.
10	David W.	28	May 11	Tibia and fibula, middle	May 11	Sept. 15	" "	Tibia protruded; sharp hemorrhage. See record.
11	Albert S.	10	Mar. 12	" " "	Mar. 12	Apr. 24	" "	Fractured by direct violence; tibia protruded. See record.
12	Jno. B.	29	Mar. 27	Tibia and fibula, lower third	Mar. 27	June 15	" "	Fractured by direct violence; piece of fibula removed. See record.
13	Owen K	37	April 21	Tibia and fibula, middle	April 21	Aug. 1	" "	Large abscess formed. See record.
14	Dan. R.	63	Nov. 3	Femur, middle	Nov. 7	Jan. 8	" "	Tibia and fibula on same side also broken. See record.
15	Wm. L.	28	Oct. 22	Tibia, lower third	Nov. 3	Dec. 8	" "	
16	M. R.	16	May 11	Tibia and fibula, middle	May 12	Jan. 17	" "	Femur on same side also broken.
17	Ann H.	28	Mar. 2	Femur, middle	Mar. 3	May 14	" "	Fractured by direct violence; œdema of labium. See record.
18	Jas. H.	45	Jan. 13	Femur, middle	Jan. 13	Mar. 1	" "	Fractured by direct violence. See record.
19	Mat. H.	32	Jan. 24	Tibia and fibula, middle	Jan. 24	Mar. 28	" "	Fractured by indirect violence; small opening. Emphysema and extravasation.
20	Jas. A.	22	Feb. 3	Humerus, middle	Feb. 3	Mar. 9	" "	Small wound; abundant venous hemorrhage.
21	Henry M.	21	Aug. 11	Radius and ulna, lower third	Aug. 11	Sept. 12	Imperfect union	Patient a sickly man; wound small.
22	Jno. R.	30	Feb. 17	" " "	Feb. 17	.....	" "	Had necrosis.
23	David H.	30	Jan. 28	Tibia and fibula, lower third	Jan. 28	.....	Good union	Tissues emphysematous and distended with blood.
24	Wm L.	28	Oct. 22	Tibia, lower third	Oct. 22	Nov. 30	" "	Struck by locomotive; wound small. Bad scalp wound also.
25	Jas. M.	9	Dec. 7	Tibia and fibula	Dec. 7	.....	Necrosis but good union	Fractured by direct violence. See record.
26	Jas. McD.	37	Oct. 30	Tibia and fibula, lower third	Nov. 5	Jan. 16	Good union	Fractured by direct violence. See record.

We have 26 cases in all, 12 of tibia and fibula, 5 of tibia alone, 1 of humerus, 3 of radius, 1 of ulna, 1 Pott's fracture, and 3 of the femur. The average time of union, so far as given, is 63 days. 20 occurred from direct violence. 23 were put up at once, or within 24 hours after receipt of injury. Of course a great many more cases of compound fractures are recorded in which the plaster splint was used, but as these died from the shock of the injury, pyæmia, septicæmia, or other cause plainly not dependent in any way upon the method of dressing the fractured limb, I have not introduced them here.[1]

Some of these cases were so complicated and otherwise interesting that I give herewith a brief synopsis of the history.

Case VII.—Peter G.; this patient received a simple fracture of the tibia and fibula Nov. 17, from being run over by a light wagon. Contusion not very marked; fracture nearly transverse; gypsum splint applied next day, and patient allowed to go about on crutches. Splint cut down before it hardened, and reapplied with dry bandage. Patient was comfortable until Nov. 28, when he began to feel dull, heavy pain over site of fracture, and drew my attention to a discoloured spot opposite that point, outside of the splint. Removing the splint, I discovered that a small abscess had formed and burst—the abscess communicating with the fracture. Small pieces of bone subsequently came out. A fenestrated splint was applied, and he made a good recovery.

This case goes to prove the porosity of the splint, and its property of transmitting intelligence of the kind cited, viz.: The bursting of a small abscess, not accompanied by sufficient inflammatory or other constitutional symptoms to call for complete inspection of the limb prior to its bursting.

Case VIII.—Wm. W., age 15. Patient fell four stories, striking on his feet. When admitted, he was found to have a fracture of the right external malleolus, opening into the joint. There was also a fracture of the internal malleolus. There was a small wound over external malleolus communicating with the point of fracture. The leg was put up, within four hours after the accident, in a fenestrated splint, the front and sides being left exposed. Necrosis followed, and eighteen small pieces of bone were taken out at intervals. This patient reported to me seven months after the injury, and could then walk without a cane; the wound had completely healed, and there was some motion at the ankle-joint. Owing to loss of substance, the foot is canted to the inner side, so that he is obliged to wear a compensatory sole. Amputation was seriously discussed in his case. His pulse never rose beyond 112, though there was at times considerable pain. After being discharged from the hospital, while yet on crutches and coming back to be dressed, a plaster bandage was put on

50 ~~28~~ fract. femur.

[1] Of the ~~28~~ cases just given, 21 were treated in wards to which the author was attached, and the measurements in many of these cases were confirmed by other surgeons, and particularly by those opposed to this treatment. The fact that the worst results are in cases which were kept in bed may indicate that the weight of the splint keeps up extension when the patient is on crutches.

by the figure of 8 turn afresh every dressing, as there was a strong tendency of the foot to luxate inwards.

This may serve to disabuse the minds of some of the idea that the application of a gypsum apparatus necessarily takes a great deal of time, for here was a case in which it was applied afresh two or three times a week, as the readiest way of dressing the limb.

Case X.—David W., age 28. On May 11 patient fell down a hatchway, and a case of gunstocks, weighing about two hundred pounds, fell after him, striking his left leg, producing a compound fracture of the tibia and fibula, near the middle. The sharp upper fragment of the tibia protruded through a wound in front about half an inch long. There was very troublesome venous hemorrhage, and the wound pulsated violently. Patient still suffering from shock, the splint was applied at once and a large fenestra cut. Wound treated with Lister's antiseptic dressing; injected with strong acid carb., and pressure applied. This checked the hemorrhage after about twenty-four hours.

13*th*. Still strong pulsation all around the wound. Firmly bound down with oakum to support.

14*th*. Pulsation gone. Lac plaster excoriates, and is left off.

June 1. Doing very well; very little pain and good appetite.

3*d*. Considerable pain; pulse 120; skin hot.

5*th*. Sharp chill; ordered quinia.

29*th*. Has had no more chills; wound nearly closed.

This patient subsequently had necrosis, and the dead bone becoming loose before the union of the surrounding bone was strong, I removed it through the fenestra in the splint. Patient was discharged cured in about six months from accident.

This case illustrates what may be done with the gypsum splint, with careful watching of the state of the circulation. I confess to having felt some fear, and to having been strongly tempted to remove the splint and place the leg in a fracture-box when I saw the whole surface exposed in the fenestra throbbing strongly. I pinned my faith, however, to the circulation in the toes and the absence of grave constitutional symptoms. This case also illustrates how an operation for necrosis may be performed through a fenestra in a splint earlier than otherwise, as previously alluded to.

Case XII.—Jno. B., age 27; healthy labourer. On March 27 his leg was caught between two heavy stones. Sharp hemorrhage; fracture compound and comminuted; great contusion and swelling; opening on each side, opposite fracture, both leading down to bone, and from the external one is sharp hemorrhage; piece of fibula, one inch long, removed from external wound; fracture of tibia and fibula low down; patient's general condition good; pulse 90; plaster splint (interrupted variety) applied within two hours from date of injury; Lister's antiseptic dressing used. The pulse in this case did not rise above 104, nor the temperature above 100°. He took no anodynes, and always said he felt comfortable. There was very moderate discharge, not averaging ℥j a day. He was kept in bed about five weeks, and was discharged cured, August 7, able to walk quite well.

This case is noticeable for the absence of any constitutional symptoms whatever, and yet it was a case that many good surgeons would have condemned to amputation.

Case XIII.—Owen K., age 26, was run over April 21, by wheel of loaded coal-cart. Free hemorrhage; fracture of tibia and fibula at middle; probe passes between fragments, and touches tibia at point of fracture; wound about one inch long over fracture of fibula. Put up within twelve hours in "interrupted" splint. Lister's dressing used.

May 1. No marked constitutional symptoms; pulse less than 115 and temperature less than 101° since last note; leg dressed every two days; discharge very moderate.

June 1. New splint, not "interrupted," but simple fenestrated; patient allowed to go on crutches; superficial abscess has developed near wound. Complete cure in five months.

The "interrupted" splint was used here at first because of the contused condition of the soft parts on the inner side of the leg, which it was desirable to have under observation.

Case XIV.—Daniel R. Patient was run over on Nov. 3, by a loaded truck, the fore wheel passing over his thigh, and the hind wheel over the leg of same side. He is found to have a compound fracture of the right femur, near its middle—the wound being entirely over the seat of fracture. Wound small; probe touches bone. There is also simple fracture of right tibia and fibula, near the middle. The leg was put up in a gypsum splint, extending nearly to the wound, the leg being slightly flexed upon the thigh; after this had hardened thoroughly, it was found that traction upon it caused no pain of account, and the thigh was enveloped in a continuation of the splint—traction being made from the lower part. The wound discharged freely for some days a dirty and offensive pus, but it closed after three weeks, and January 8 the splint was removed, and good union of the tibia and fibula found, with good position. The union of the femur was also good; but there was some anterior deformity caused by the upper fragment. The length I could not get by comparison, as there was an old unreduced luxation of the head of the femur of the same side upon the "dorsum ilii."

This case shows that in fracture of the femur, complicated with a fracture lower down, the surgeon need not necessarily give up extension—for this man would allow all the extension that two men could make by pulling upon the splint below—the traction seeming to be mainly received by the anterior and lower surface of the thigh. This probably caused the anterior deformity of the upper fragment, which, in a similar case, I should take special measures to prevent. That the traction did no harm to the fracture of the leg, is shown by the result. The principle is, of course, applicable to any number of fractures not *too* close together, viz., first extending the splint over the most distal one, and then using the continuity thus given in manipulation for the reduction of the next.

Case XVII.—Ann H. was struck March 2, on right thigh, by a piece of machinery which flew from a revolving wheel. She says the thigh bent so that the right knee lay upon the middle of the sound thigh. I found a

fracture at the middle, with shortening 1¼ inch, and great swelling. There was a small wound on outside of thigh, through which a probe touched bone.

March 3. Plaster splint applied; large fenestra cut over wound.

16*th*. Patient trying to get out of bed alone, fell, and broke the splint, which was then removed. The so-called "Bucks extension" was then applied for two days. Patient had no constitutional symptoms whatever. The discharge from the wound has been trifling.

18*th*. Splint reapplied.

19*th*. Considerable œdema of left labium, and some scalding in micturition.

21*st*. Œdema gone; patient sits up all day, but is awkward in using crutches. Discharged cured May 22, with ⅛ inch shortening.

The œdema in this case was the first I had seen, and it resulted apparently from the pressure of the upright bar during the application of the splint, as it was in the labium of the opposite side, and not where it could be explained by pressure of any part of the apparatus.

Case XVIII.—James H. Compound fracture of right femur, just above the middle. He was caught between a coal-box and a coal-cart, which was backing up to it, and crushed. There was a large opening over the apex of Scarpa's triangle, admitting two fingers down to the broken bone; strong tendency of upper fragment to project anteriorly; lower fragment was brought into line by raising the knee and making extension; gypsum splint put on in this position, while patient was relaxed by shock of accident; large fenestra cut over wound and leg swung from cradle. This patient made a speedy recovery, without having had ℥j of discharge from the wound, and with a pulse never above 96 and temperature never above 100°. Result, good union, with ¾ inch shortening. The wound was dressed simply by oakum, bound on.

This case is, in some respects, the most remarkable of all, from the crushing nature of the injury, the extent of the wound, the freedom from constitutional symptoms, and the union of the wound almost by first intention.

Case XXIII.—David H. Patient's leg was run over by wheel of truck. Fracture of tibia and fibula at junction of middle and lower thirds; bone protruded; much venous hemorrhage; opening small; tissues emphysematous and distended with blood up to knee. Was put up at once in "interrupted" splint. Pulse never above 96; temperature not over 102°. Patient out of bed in three weeks. Good union.

This is another case of absence of constitutional symptoms. In this case, after the splint had hardened, there was some deformity, which was remedied by cutting the connecting band, rectifying the position, and applying a new connecting piece over the old one, showing that in a case of this kind it is not necessary to reapply the apparatus from the beginning.

Case XXV.—James M., age 9. December 7, a heavy iron fly-wheel fell on both legs, producing a compound, comminuted fracture of the right tibia, with a wound about two inches square, over and communicating with

it; also a simple fracture of the left tibia, with an immense lacerated wound on the outer and anterior surface of the left leg. This fracture became compound a week afterward. Both legs were put up at once in the "interrupted" variety of the gypsum apparatus. He had tolerably severe constitutional symptoms once, resulting from the suppuration of a large extravasation of blood which was on the outside of the right leg, and was opened. He had necrosis of the right tibia, but subsequently made a complete recovery in both legs, and was able to walk and run perfectly.

Case XXVI.—Jas. McD. Patient fell, October 30, and struck on an iron chain, breaking his right tibia and fibula at junction of middle and lower thirds. A large piece of bone, nearly the whole thickness of the tibia and three-quarters of an inch long, was removed from the wound. Tissues boggy—leg shortened one inch—put up Nov. 5 in interrupted splint. He made an excellent recovery.

~~Both~~ The two preceding ~~following~~ cases were under the charge of Dr. J. D. Bryant, late House Surgeon at Bellevue Hospital, and in both the author assisted Dr. B. in putting on the apparatus.

Of the cases given in detail, Nos. 7, 8, 10, 12, 13, 14, 17, and 18 were under the author's personal care, and he can vouch for the correctness of the particulars.

Another and more recent case may be adduced, illustrating the application of this apparatus to a fracture not yet alluded to. The history of this case in brief is:—

Thomas C., age 25, single, plumber by occupation, on November 7 fell from a ladder about forty feet, striking on the right side of his head. On rising, he found that his head fell forward upon his chest, and he had no control over it. He had also great pain in the back of the neck. He received treatment, but got no better and came to Bellevue Hospital, November 28, complaining of this pain and loss of control over his head, with constant fear of moving around. The injury was diagnosed as fracture of the transverse process of one or more cervical vertebræ. Patient was kept in bed, as quiet as possible. December 11, somewhat improved. Can bend his neck slightly forwards and laterally, but uses his hands to raise his head from the pillow. He was then put up by Dr. Cushing in a gypsum apparatus made by placing a wide folded strip of "soaked blanket" down the back of his neck and fastening the head to it by circular turns of a plaster bandage around the forehead. The lower end of the strip was secured to the back by similar turns of bandage around the body and across the shoulders, making a sort of jacket with armholes. This apparatus afforded him entire relief from pain in moving about; and from the constant fear that something would happen if he moved suddenly. The apparatus was removed after about six weeks and the man discharged cured.

In conclusion, we will state, in a few words, what we have endeavoured to prove, and to rehearse the means by which we have endeavoured to prove it. I subjoin them arrayed in a tabular form:—

I. To show that the results are at least equal to those of any other instrument, and in some fractures better. To support this ground I adduce

192 cases of simple fracture (50 being of the femur) and 26 cases of compound fracture.

II. That union is not delayed by this splint, as alleged by some. On this point bear 313 cases, 192 of the gypsum apparatus and 121 of the starch, felt, leather, and pasteboard.

III. That the splint may be with safety applied at once in fractures of all bones. In support of this point are 176 cases in which this splint was applied within forty-eight hours from the date of the accident, of which 69 are simple and 23 compound fractures (gypsum apparatus), 23 are simple fractures (felt splint), and 61 simple fractures treated with gypsum splints, of which I could not get complete details as to results, the patients having been discharged from the hospital wearing the splints, etc., but whose records are given beyond the date when we may be sure that no untoward result could arise dependent upon the early application.

IV. To show that great contusion of soft parts, swelling or extravasation of blood do not, of necessity, contraindicate even its immediate application. Here belong 32 cases of simple fracture and 23 of compound fracture thus described.

NOTE.—The author desires to acknowledge the valuable assistance of different members of the present and late House Staff of Bellevue Hospital in preparing this paper. The names of several of them are indelibly associated in hospital memories with the introduction and progress of the gypsum apparatus, and more than one of the visiting surgeons have expressed the belief that the remarkable success attending the use of this apparatus was dependent quite as much upon the skill and intelligence shown in its application as upon the inherent merits of the apparatus itself.