The following is the report of the condition of the kidney:

This shows a condition of focal nephritis with evidence of several acute attacks recent in date.

Capsule thickened in patches. Blood vessels do not show arterio-sclerotic changes. Glomeruli normal in places; in others they show capsular fibrosis and fibrosis or atrophy of glomeruli; elsewhere there are intracapsular exudation, cell proliferation, and fibrosis. The interstitial tissue is increased in patches, and contains many areas of lymphatic spaces laden with fat.

The convoluted tubules are almost normal here and there, but to a great extent show cellular degeneration, especially fatty desquamation and degradation of the lining cells and granular debris in the lumen. Some show dilatation, and a few cystic spaces are present in the subcortical area.

The heart shows interstitial myocarditis in some areas.

The spleen, suprarenal, and pancreas are normal.

So far as this case goes it would confirm the clinical evidence, which points to this form of nephritis as being a diffuse nephritis, affecting chiefly the convoluted tubules, but not especially the vascular elements of the kidneys. The characters of the urine, with its rather low specific gravity, excretion scanty at first and later as a rule abundant, moderate or large amount of albumin, and with numerous hyaline, epithelial and granular casts in the early stages, correspond to a change of this kind.

To sum up, in cases of nephritis at a base hospital, the general clinical features perhaps especially characteristic are the benign character of the nephritis in the large majority, the frequency of pulmonary complications, especially bronchitis, oedema of lungs, and broncho-pneumonia, apart from these complications a not infrequent dyspnoea, the generally good appetite, clean tongue, and maintenance of fair nutrition, and, on the other hand, infrequency of anaemia, of marked uraemic symptoms, and of a high blood pressure or cardio-vascular changes. The short duration of the illness in most cases would explain some of these latter departures from the usual symptoms of other types of nephritis. Severe retinitis or optic neuritis is uncommon—3 out of 80 cases.

I regret that more thorough investigations on the blood and on the excretion of uric acid, creatinin, etc., could not be carried out, and in conclusion it is my pleasing duty to thank the resident medical officers at Southmead Hospital, especially Captain H. H. Carleton, R.A.M.C., for much help in taking blood pressures and other investigations, and Professor Walker Hall, of the University of Bristol, for pathological reports, and to express our great indebtedness to the Medical Research Committee for their help in maintaining the pathological laboratory at Southmead Hospital, in which the urinary examinations were carried out.

REFERENCE.

¹ Davies and Weldon: *Lancet*, 1917, vol. ii, p. 118.

REAMPUTATION.

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ASSUMING that a reamputation of a limb has to be done, at what period after the primary amputation should it be undertaken?

The practice of surgeons differs widely. Some wait for healing and a "clean" operation which often takes months. But an experience of the use of button-sutures threaded through vulcanite boat-shaped buttons or india-rubber tubing acting as a support for the flaps and taking all the tension off the skin stitches shows that it is possible to reamputate in the presence of suppurating surfaces with almost complete certainty of union either by first intention or a kind of second intention, with preservation of the apposition of the flaps and the covering of the end of the bone.

Men upon whom an urgent amputation has been done in France arrive at hospitals in Britain after an interval varying from several days to a week or two.

If the amputation has been of the guillotine variety, the incision in the skin has been clean and circular, the skin is retracted up the limb, the muscle surfaces have retracted to a lesser degree, the end of the bone is exposed and protruding, and all the surfaces are bathed in pus.

Sometimes flaps have been attempted and a similar

condition exists, with the addition that the flaps may be large, hanging, and ragged at the edges from stitches which have cut through owing to suppuration.

My own invariable practice ever since the commencement of the war has been to allow these cases to settle down in hospital for a few days and then to reamputate, stitching the skin edges together as for a clean operation. During the waiting days the exposed surfaces are dressed with moist antiseptics, and when the general condition (usually disturbed by the journey and the necessary handling) has improved, the resistance has reached its maximum and the temperature has become steady, though slightly elevated, the patient is considered ready for operation.

When there was nothing other than the condition of the stump to consider reamputation has, as a rule, been done within a week or ten days of the patient coming in.

In no case have the skin and soft tissues failed to heal over the end of the bone by either first or second intention, with at worst, and rarely, a small granulation area at the point where the drainage tube was left in for the first twenty-four or forty-eight hours; or where some pus had formed at a skin stitch or between two stitches. Even when this pus has formed it has not interfered with the complete healing of the soft tissues over the end of the bone and the union of the skin, usually within twenty-one days. In no case has the end of the bone appeared or been exposed even to the probe after a reamputation. That this is not the general rule there is abundant evidence at the Pavilion Military Hospital for Limbless Men. It would appear that reamputations have been done and the bone shortened, but that the condition of the stump has reverted to its original state, the skin and other soft tissues retracted, and the bone exposed, the only difference being that the limb is shorter.

The secret of healing by primary or by secondary, or rather delayed primary, union in septic cases is the relief given to the skin stitches by the "button-sutures" planted well back from the incision, and arranged staple-wise in such a way and position as to bear the whole weight of the flaps and keep them in apposition.

The "second intention" to which I have referred is a union in the presence of or following suppuration affecting the skin edges, but not sufficient to separate those edges from each other (either by the stitches cutting through or by sloughing) to such a distance as to prevent the epithelial margins from uniting without the intervention of a granulation area.

As the button-sutures carry all the weight of the flaps and bear all the tension, the skin stitches have no other function than to keep the skin edges opposite one another and prevent bulging of subcutaneous tissues. In short stumps the loss of another inch of bone by reamputation may seriously curtail locomotion. With button-sutures less provision has to be made for long flaps to meet contraction, and therefore valuable length is saved. These button-sutures tend also to keep the severed tendinous ends and muscle edges in apposition over the end of the bone. This either gives attachment between the two groups of locomotor muscles over, or it gives attachment to, the end of the bone. If it unites by close fibrous intervention over the end of the bone the result is a greater muscle purchase, and therefore a greater power of movement of the stump than would follow an attachment higher up the shaft, which is usual when muscles are allowed to retract after amputation. Moreover, a muscle shortened by contraction and attachment higher up suffers the disadvantage in "pull" that a rower does at the end of his stroke, as compared with the advantage at the commencement, when his arms are fully stretched and the point of "attachment" to the oars most distant from the base to which they have to be drawn. It should never be forgotten that a stump is a locomotive organ as well as a weight-carrying organ, and will have to swing and control an artificial limb often as heavy as 7 lb. It is also of advantage to get a substantial boss of soft tissue over the end of the bone. Even if atrophy takes place under muscle pull or from the pressure on an end-bearing stump the residuum is something to the good. In my opinion an effort should always be made to get a stump that will stand the pressure of the body weight. Even if this may not be urgently required, as in a short thigh stump, it has certainly two advantages—it shares the body weight with the tuber ischii, and, from the sense of firmness and

compactness it gives the man, he has a better control over his artificial limb.

The normal heel is the ideal stump. It is dome-shaped; it is covered with true skin, which thickens and hardens with use; it has a boss of fat, honey-combed with connective tissue, and it has a dome-shaped bone-end covered with periosteum. Every amputation should aim at giving a stump having these characters.

As a typical case of reamputation through the thigh, take an emergency operation done in France through the knee-joint. The condyles of the femur are exposed, the cartilaginous surfaces are ulcerating off, and the bone is carious when the case comes to Britain.

Four weeks have elapsed since the first amputation. A long anterior and a short posterior flap are dissected up in the lower third of the femur, sufficient of the muscular tissues being included in the flaps (but at a slightly higher level) to cover the end of the bone completely and easily with muscle. A circular incision is made through the periosteum well to the distal side of the point in the femur where it is to be severed with the saw, and a cuff of periosteum turned back little by little with the aid of a periosteal elevator, care being taken not to split or tatter or buttonhole this periosteal cuff. If the periosteum is rolled back one-eighth of an inch at a time, it will not split into ribbons, a defect in technique that tends to favour the formation of spurs. These spurs in many cases appear to be the result of grafts arising from osteoblastic cells from the sawdust distributed along the line of the saw edge. To prevent this I follow the plan of having the muscle and soft tissues well covered and retracted by a cotton-cloth retractor during the sawing and then washing the bone dust away thoroughly with 1 in 1,000 perchloride solution before the retractor is removed. Any muscle tissue that has been torn with the saw should be snipped away.

After the bone has been sawn through and the sharp edges rounded by a file or cutting forceps, and the vessels picked up with artery forceps, the nerves are found and cut back. I have followed the practice of making a circular incision through the sheath of the larger nerves, and then with a dry gauze swab rolling up the sheath beyond the point at which it is intended to sever the nerve. This allows the nerve end to be covered with its sheath in a manner somewhat similar to the periosteal covering provided for the end of the bone.

After all vessels have been tied, a purse-string catgut suture is stitched round the free edges of the periosteum, and then tied in such a way as to cover the end of the bone completely. If suppuration take place beyond this, the bone is protected.

The next step is to put in the "button-sutures." If boat-shaped vulcanite buttons are not available, rubber tubing can be used and button-sutures prepared by the theatre sister. These consist of two silkworm-gut sutures knotted through a piece of rubber drainage tube 1 in. to 1½ in. in length and the size of a slate pencil, or through the vulcanite boat shaped buttons.

If rubber tubing is used, the silkworm-gut threaded on a needle is passed through the substance of the tube near its cut end, and then along the lumen of the tube to about the centre of its length. The needle is then made to pierce the tube and emerge on its outside. The other silkworm-gut suture follows a similar route from the other end of the tube, and then the two ends are knotted with a reef knot on the outside of the tube at its centre.

This double silkworm-gut suture thus prepared is now inserted in the lower flap about 1 in. or 1½ in. from the skin edge, staple fashion, with the tube parallel to the line of incision, and the ends are then carried through the anterior flap about 2 in. or 2½ in. from the skin incision. The ends are then threaded through a piece of tubing (b) similar in length and size to its mate (a), but having an eye cut out of its middle by the scissors, through which the ends of the silkworm-gut are made to emerge from the lumen of the tube after having been passed through either end.

The ends are then knotted after the flaps have been compressed well in apposition, and the skin edges are then sutured in the ordinary way, a small drainage tube being

placed in one angle of the wound. The whole wound and the buttons are then sprayed with iodine, and the stump bound upon a Gooch splint.

These button-sutures keep the flaps in apposition and prevent sagging. They also prevent oozing of blood between the flaps and the formation of a miniature haematoma. They thus tend to prevent haemorrhage by the pressure which the flap surfaces are made to exert against each other. But their great virtue is that they defy the results of suppuration. The skin underneath the buttons may, and sometimes does, ulcerate at the point of passage into the skin of the silkworm-gut, but in my experience the skin has rarely given way or failed to support the pressure of the buttons in such a manner as to allow the flaps to part. The skin has thus no tension to bear and the edges readily unite. Tension, and not pus, is the enemy of union.

If profuse suppuration occur, and pus oozes between and around the skin stitches, they can still be left *in situ*, and small tubes may be inserted here and there between them. These skin sutures may even in the course of eight or ten days cut through, but as there is no tension to speak of tending to part the edges, they do not part. All the time the button-sutures, being some distance back beyond the troubled edges of skin, are free from pus and carry the whole weight of the heavy flaps and counteract contraction. The channels of these button-sutures may even suppurate and pus may well up along one or more of the strands of silkworm-gut. But they do not give way and the healing and restoring processes are going on all the time, till, in from ten to fourteen days, the wounds are either quite healed or sufficiently healed to do without the aid of the skin sutures, and finally in a few days later the button-sutures also.

The importance of this method of dealing with stumps lies in this, that the reamputation can take place at almost any time after the primary operation, notwithstanding that the stump is septic, with the practically certain assurance that the flaps will not part nor the end of the bone uncover.

The following are individual cases illustrating these points:

CASE I.

Pte. D., wounded August 6th, 1916. Thigh amputated in lowest third three days later (August 9th). He arrived in England twelve days later (August 21st). The stump had been covered by anterior and posterior flaps, but the whole had suppurated, the stitches had cut through, the flaps had separated, were bathed in pus, had sloughing edges in parts, and were hanging free. The bone, denuded of periosteum, was protruding about 1½ in. It was seventeen days later before the sloughs had separated and the flaps were brought to a condition of normal cleanliness for granulating surfaces. One of the flaps had several "fingers" made in the margin by the original stitches having cut through.

On the seventeenth day after his arrival in hospital here, the stump was reamputated. The bone was removed at a point beyond the ring of callus and high enough to give a periosteal cuff; the "fingers" were trimmed off, the flaps slightly extended upwards by incisions at their base, and the whole stitched up and completed as if it were a "clean" operation. Button-sutures were put in, the skin edges were closely stitched, and two small drainage tubes were put in at either angle of the wound.

In this case the granulating surfaces of the flaps were brought in apposition by the button-sutures, but in some parts granulating surface came in apposition to a clean cut surface. Seropus discharged from the tubes and they were kept in for five days. Pus appeared at three other points in the incision. No skin stitch completely cut through, and on the tenth day several of the looser ones were removed. Between most of the skin stitches the edges had united by first intention.

Small quantities of pus oozed from some parts of the edges and the stitch channels for several days longer, but by the twelfth day all the skin stitches were out and all the edges were united either by first intention or by second intention, except at three points—the two drainage tube openings and one small point in the centre where the edges were sufficiently parted to allow of granulations to appear. The button sutures were removed on the twelfth day. In three weeks the whole had healed.

CASE II.

Pte. B. was wounded in France on June 25th, 1916; was amputated through the middle of the thigh four days later, and arrived in hospital in England on August 21st about eight weeks after his first amputation. The skin and soft tissues had retracted and about one inch of bone protruded. On August 26th—that is, five days after his arrival—he was reamputated. The incisions necessary to prepare anterior and posterior flaps of equal length were made at the edge of the skin just before it merged into the epithelial margin, so that skin to skin was brought into apposition by the skin sutures. The rest of the operation was similar to Case I and the whole

healed by first intention, a little moisture from sero-pus being not sufficient to interfere with this process or delay it.

CASE III.

Pte. E., wounded July 4th, 1916. Amputated in uppermost third of thigh August 4th. The thigh was massive, and the patient was fat. The stump was very short. A large cauliflower granulation covered the end of the bone. This was surrounded by a broad band of cicatricial healing, and beyond this there were retracted and fleshy soft tissues.

On November 30th an incision was made along lines separating the skin and the cicatrix and the whole cicatrix and the granulation mass dissected off in one piece. On separating the cauliflower granulations a ring sequestrum was struck, and this was separated also. The skin and subcutaneous tissues were freely dissected up to allow of sufficient flap area to cover so large an exposed area and the protruding bone. This was accomplished, and two sets of button-sutures were put in. The skin edges were closely sutured as for a clean operation, and two small drainage tubes were put in at opposite angles in the wound.

The whole of these extensive edges healed by first intention, except the drainage tube openings, which united by second intention. The button-sutures were removed on the twelfth day, two days after the last of the skin stitches.

On the thirteenth day, all the edges having been firmly united, the temperature rose, there was much pain, and fluctuation appeared at the outer angle of the stump. So securely were the edges united even over this area that neither a sinus forceps nor a sharp probe was able to penetrate the cicatrix, and the abscess had to be opened along the line of union by a sharp-pointed bistoury in the ordinary way.

After three days this abscess evacuated, and the whole was securely united on the twentieth day. The man says his stump is lengthened, which is true. It is lengthened by the thickness of the skin and subcutaneous tissues covering the end of the bone.

CASE IV.

Pte. W. Amputated through lowest third of thigh. On arrival at hospital the end of the bone covered by granulations protruded about $\frac{1}{2}$ in. beyond the epithelial margin of new skin, and the band of new cicatrix was about $\frac{1}{2}$ in. wide. The skin and soft tissues were much retracted.

On November 11th, two elliptical incisions were made in front and at back of the protruding bone, and about two inches of bone was dissected out and removed. Similar treatment to the above was followed. This stump suppurated badly. The temperature was high, the pain was considerable, and the stump swelled considerably, putting much tension on all the sutures, so much so that the buttons of the button-sutures were half buried in the skin. Pus welled out from between the skin stitches and from the drainage tube openings. But the button-sutures stood the test, and the edges united by the second intention. The two tube-openings and one central point where a small tube had been put on the fourth day showed granulation points of the size of split peas for several days longer, and then healed over on the twentieth day, and he left for a week's leave on the twenty-first day.

In the absence of button-sutures all the above cases would have hopelessly broken down, and the last state would have been worse than the first—the bone shorter, the granulating surfaces greater, and convalescence much protracted.

There are two factors that favour union in this method of reamputation. One is the increase in general vascularity that follows primary amputation. The largest vessels atrophy, but the small ones dilate. This dilatation of the numerous small blood vessels makes provision for a more general blood supply throughout the operation area, and guarantees a higher vitality. The pressure of the buttons is therefore of little or no consequence.

The other factor is that the skin and muscular tissues have already contracted to their maximum. There is little fear, therefore, of a further contraction when the attachments that have followed the primary amputation are disturbed by the reamputation. Shorter flaps will therefore suffice, and the "pull" over the end of the bone exerted against the button-sutures is less than one would suppose.

A consideration of these points would lead one to suggest:

1. Early reamputation and the saving of weeks of painful and tedious healing.
2. The control of bony proliferation, the avoidance of spurs, and the protection of the bone-end from infection, by careful technique in the treatment of the periosteum.
3. The covering of the end of the bone with muscle fascia and skin in such a way as to (a) approach the normal heel as a model and (b) provide for the most distant muscle attachments possible.
4. The use of button-sutures in every case of primary and secondary amputation where the flaps are large and the skin is stitched, in order to (a) keep severed muscles and tendons as nearly as possible

in apposition, (b) give immunity from the results of suppuration if it occur, (c) prevent haemorrhage between the flaps, (d) give the minimum area of flaps and the maximum length of stump where shortness is a locomotive disability.

A METHOD OF FLAPLESS AMPUTATION, WITH SUBCUTANEOUS DIVISION OF THE BONE AT A HIGHER LEVEL.

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THE guillotine method of amputation as practised during the present war conveys at the first glance an impression of brutal simplicity which carries one back to the primitive ages. Nevertheless, it is probable that this method is one of the most valuable innovations the war has brought forth, and that for certain conditions it is the Omega as well as the Alpha of the subject of amputation. Its introducer, Captain Fitzmaurice Kelly,¹ is to be congratulated on his clear vision and courage. The main advantage gained by the method is that it exposes to infection the absolute minimum of raw surface.

The method is, however, attended by certain disadvantages and inconveniences. In some cases the skin eventually succeeds in spreading over and covering the exposed end of the bone. But even in these rare and favourable cases the bone is adherent to the skin. In the majority of cases the exposed end of the bone undergoes necrosis, owing to a simple acute osteomyelitis extending a little up the medullary canal. After the separation of the necrosed fragment a really good stump might conceivably result. But in point of fact the end of the bone always becomes adherent to the skin. Two cases recently under my care presented very similar conditions, and may be taken as typical. A bare necrosed piece of bone, still continuous with the living portion of the bone, projected from a raw, granulating surface corresponding to the original section of the limb. This surface was much smaller than the original cross-section owing to the spread of epithelium over the end of the stump and the contraction which always accompanies this process. In the neighbourhood of the bone this layer of granulation tissue becomes calcified or ossified almost up to its free surface, and adhesion of the bone to the skin is the inevitable result. Thus, in nearly all cases of guillotine amputation a secondary operation is imperative. The object of this paper is to suggest the trial of a method which, while retaining all the important advantages of the guillotine method, will obviate the necessity of a secondary operation. It is also, I think, the best way of doing the secondary amputation in cases previously submitted to the Kelly method, and with such cases I propose first to deal.

Secondary Amputation Following the Kelly Amputation.

In such cases it is necessary (a) to remove such a length of bone that an adequate covering of soft tissue is provided for what remains. (b) To excise the calcified granulations, which do not afford a suitable bed for the spreading epithelium. If calcified granulated tissues are allowed to remain, it is certain that ultimately the skin will be adherent to the end of the bone. (c) To do what is necessary with minimum exposure of fresh raw surfaces, since all these cases are necessarily accompanied by sepsis.

It is obvious that a formal flap amputation is unnecessarily extravagant and that it fails to fulfil the third requirement of a minimum exposure of fresh raw surface. This method, therefore, need not further be considered.

In the first case upon which I operated I made two lateral cuts upwards through the soft tissue at the side of the stump, thus fashioning two rough flaps. The bone was sawn through at the base of these flaps and they were then brought together by a few points of suture. This operation was followed by an alarming febrile disturbance, which, however, subsided in a few days. Its ultimate result was not satisfactory, for the skin was adherent to the bone. I had omitted to observe the second requirement—namely, to remove the ossified granulation tissue