

## GUNSHOT WOUNDS AND LESIONS PRODUCED BY SHELL AND SHRAPNEL IN THE JAWS AND FACE.

By Leo Eloesser, M. D., San Francisco, Assistant Clinical Professor of Surgery, Medical Department, Stanford University.

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THIS war has not only developed much that is new, it has brought back much that is old; together with aeroplanes and submarines, Zeppelins and tanks, men have come back to bayonet fighting, hand to hand conflict with knives and sabres, and the most elementary means of combat. The wounds therefore are of the most varied nature. Before considering the various lesions it may be of interest to review the arms by which they are produced.

Wounds caused by knife, bayonet and sabre-cuts will be of little interest to you. They but rarely affect the dental apparatus. Their frequency in this war, however, has been considerable, more than hospital statistics show, because when a man thrusts with a bayonet in a hand to hand fight he thrusts to kill, and the victim rarely lives to reach a hospital. Of more concern to us are the injuries produced by firearms, by the classical infantry weapon, the rifle, by the machine gun, which is in reality merely a rifle worked by machine power, by hand grenades and bombs, and by the various kinds of artillery.

All the combatants in the present war use a bullet more or less cylindrical in shape; some have parallel sides, except at the tip, which is pointed; others are ogival, or cigar shaped. The old leaden bullets would melt in the barrel of the

rifle under the modern high explosives, so that the lead has to be encased in a jacket of more resisting material, steel,

Figure 3.



French (A) and German (B) cartridges. Bullet has been drawn out of the shell.

nickel-steel, or nickel. The English bullet has a tip of aluminum and the French bullet has no jacket, but is of solid copper. The bullets weigh from 10 to 13 grams, have a calibre of from  $6\frac{1}{2}$  to 8 millimeters, a muzzle velocity of from 6 to 900 yards per second and carry 2000 to 2500 yards. The shape of the bullet, the nature of its composition, and its enormous energy determine the kind of wounds it makes.

In the first place the shape, which

places the center of gravity toward the rear of the bullet, makes it prone to turn, to hurtle thru the air or even to fly butt end foremost. That a bullet which hurtles or strikes sidewise makes a much larger wound and much more extensive lacerations than one which strikes tip foremost is evident. If, on the other hand, the bullets fly straight and especially if they are partly spent and if they strike at long range, they may make a wound which, for military purposes—killing or crippling the enemy—is insufficient. This is notably so with small calibre Italian and Japanese bullets; there are cases of men who have been shot thru the lung and have kept right on fighting, so slight were the effects of the wound. Ammunition of this kind of course, defeats the purpose of war. The shape of the bullet not only determines its flight before it strikes its target, but afterward. At the beginning of the war, there was much talk of dum-dum bullets; one hears less of them as the effects of small calibre ammunition are better understood. Every bullet is a dum-dum bullet—potentially. Any soldier can turn an ordinary bullet into a dum-dum, or the bullet can turn itself into a dum-dum when it strikes. What is a dum-dum? It is a bullet whose tip has been removed or notched or hollowed out or otherwise deformed; so-called because this kind of ammunition was first made in a factory at Dum-Dum, near Calcutta. When a bullet with a split or hollow tip traveling at a high velocity strikes, the air pressure in the tip bursts it asunder, the bullet explodes and works frightful havoc in the tissues. Any ordinary bullet can turn into a dum-dum, or have this explosive effect—either because it has become deformed by some object it hits during its flight—a barbed wire fence or a twig, or because it has hit something inside the body which has the same effect, a hard bone, for instance. So that there is no telling from the nature of a

wound whether it was inflicted by a dum-dum or not, and the only reliable evidence on which to base the accusation of using this forbidden ammunition is to capture the unspent ammunition itself.

Of further influence on the character of the wounds is the composition of the bullet, whether soft or hard, solid or of various metals in mechanical combination. The only solid bullet, I said, is the French one of solid copper. This is the most humane, as far as the bullet itself goes. The copper is tough and the French bullet neither splits nor mushrooms nor scatters. It may inflict great lacerations, but they are not caused directly by the bullet, as we shall see later. The bullets of other combatants have a soft core and a hard jacket. If they strike a bone they tend to mushroom; the driving power of the leaden core tears the jacket into strips and it flies on, ripping and rending the tissues. Part of the jacket may stay behind and be spread about along the track of the bullet. There are a few wounds from unjacketed leaden bullets, close range pistol wounds. Here the track of the bullet is also lined with flakes and spots of lead swept off by the tissues.

The shape and composition of small calibre ammunition are of less influence in determining the extent of wounds than its great energy. The weight of the bullets being about the same, energy practically means velocity,—almost a half mile per second at the muzzle of the rifle. It is this that causes the havoc. Things have no time to get out of the way. Much has been written about "explosive effect," much is still unexplained; in many instances tho, the explosive effect is simply secondary to the great velocity of the bullet. A missile flying 5 or 600 yards a second hits a bone and shatters it; each of the fragments then exerts, on the surrounding tissues, the energy imparted to it by the impact of the bullet; each fragment becomes a bullet in itself, becomes a secondary missile;

the tissues, muscle, tendons, skin struck by these fragments impart their energy to other neighboring objects and push and pull and tear on more distant parts to which they are attached; so this play goes on until the whole energy lost by the bullet in its flight thru the body has been used up. How much force is required to break the velocity of such a bullet is

Figure 4.



Short range gun-shot wound, explosive violence. A, wound of entrance. B, wound of exit.

easy to calculate. It is not only the missile therefore, that does the damage. It is what is struck by the missile, the tissues themselves, the bone and the more unyielding soft parts; they tear and crush and bruise each other. This explosive effect is exerted mainly at short range; at a distance of several hundred yards bullets no longer seem to have an explosive violence unless they are dum-dums or hit end on or sidewise. Some authors, however, claim to have observed this effect at great distances, and think that there is only a middle zone of distance within which the explosive effect is wanting.

Besides these extensively lacerated wounds, one sees simple ones, a small wound of entrance, a tiny black slit easily overlooked, and a small one of exit, the size of a dime or less and covered with a black scab. Between these two extremes lie all possible degrees of severity. Even in the largest wounds, the wound of entrance is smaller than that of exit, and the track of the bullet has more or less the shape of a cone with the apex towards the entrance.

Figure 5.



Fragment of German hand grenade (above), shrapnel bullets (below).

The machine gun is not, properly speaking, a small arm, but it fires the same ammunition as the hand rifle and makes the same kind of wounds.

Shrapnel gives a combination of the effects of small calibre ammunition and shell. It consists of several hundred round leaden bullets enclosed together with a quantity of explosive in a steel casing. Attached to the shell is a fuse which is set for time, so that if it fails to explode on impact it does so at the expiration of a certain number of seconds, and scatters the enclosed bullets over a wide area. As the explosive charge acts but momentarily, the shrapnel bullet soon loses its initial velocity and has penetrative power only at close range, i. e., at a short distance from the point where the shell explodes. The leaden bullets are readily distorted

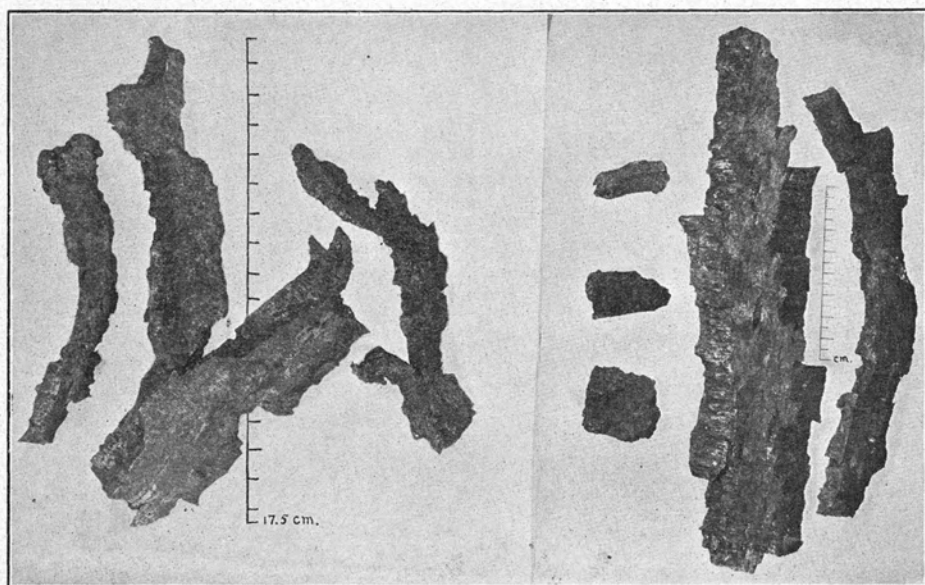
and scattered about in the wounds; one not infrequently finds them split in two.

The typical artillery projectile is the high explosive shell. Originally intended for use in demolishing fortifications, it has attained increasing importance as ammunition to be directed against the living enemy. The shell is of steel, and like shrapnel explodes either on im-

neath a comparatively small hole in the skin. Both shrapnel and shell fragments frequently lodge in the body, small arm ammunition more often pierces thru and thru.

Besides these three most common forms of missile, small calibre bullets, shrapnel and shell, the war has brought out others, most of them depending on an ex-

Figure 6.



Fragments of shell.

pact or by means of a time fuse, breaking into a multitude of large and small fragments. These pieces are sometimes more or less round or cubical, sometimes long and sharp, but always jagged and irregular. They inflict wounds that are dangerous, not only from the size and irregular shape of the projectile, but from the constant infection. The wound of entry is often smaller than the shell fragments causing it; the elasticity of the skin contracts the wound once the projectile has passed thru. It is not rare to find fragments weighing a pound or more, whole fuse caps for instance, be-

plosive violence. Among the most common are hand grenades. Where the opposing trenches are close together, 5 or 10 yards, artillery is useless and the explosives are hurled from one side to the other by hand. The French use a grenade which is thrown from a sling; the Germans have two kinds, one a small shot some 3 to 4 inches in diameter, whose steel is divided into 64 squares like a golf ball; this is "put" like a shot. The other kind looks like a tomato can on a stick; it is thrown like a hammer and carries a time fuse which peels off as the grenade leaves the thrower's hand. There

are also light trench mortars, "mine throwers" which fire a thin shell with a large charge of high explosive for short distances. They are used to shoot up into the air from one trench to the other. Wounds from the explosion of blasts are common, either burns or the result of falling rock, earth and debris. These materials, rocks, flying timbers, etc., which the exploding shell sends into the air, are known as secondary missiles and cause as much damage as the actual shells themselves. Wounds from this kind of explosive ammunition are usually multiple, often badly lacerated and always infected.

Injuries from burns are frequent, produced partly by accident, premature explosion of ammunition, etc., partly by intentional efforts of the enemy. An apparatus is used that throws an intensely hot blast-flame of tar and oxygen for 75 yards. These, then, are the weapons inflicting most of the wounds which we have to consider.

The whole character and nature of the wounds, the whole character and nature of military surgery as distinguished from civil practice is determined by infection; one fact that the present war has served to establish is that all gunshot wounds are infected—all of them. The old dictum that gunshot wounds are sterile unless infected from without, the old theories of the self-sterilization of bullets by heat developed at the moment of impact have been disproven. All gunshot wounds are infected—bacteriologically. Whether the wounded suffer from the clinical signs of sepsis depends upon the local condition of the wound, the amount of necrosis and hemorrhage, the presence of foreign bodies and dead material and the amount and character of bacterial contamination, and further upon the wounded man's general powers of resistance. But, whether infected clinically or not, all gunshot wounds are bacteriologically infected from the start. Clinically they

show much variation; whether sepsis develops depends upon local and general conditions; about one-fourth of all rifle wounds, three-fourths of all shrapnel wounds and almost all shell wounds show clinical evidence of infection and suppuration. The cavity of an open fracture containing bits of loose bone, a huge blood-clot, pieces of bruised and necrotic muscle and fat, fragments of shell, the filthy tags of a felt uniform, rocks, earth and all kinds of dirt, will lead to sepsis where the closed clean-cut track of a rifle bullet, a wound whose charred edges seal it off against the rest of the body, will heal as kindly as an aseptic operative incision. About the jaws and face, infection plays less of a part than elsewhere in the body. Wounds of the face are usually wide open, there are no great masses of musculature to confine pus and shut out oxygen. The tissues are well supplied with blood, there is less tendency to necrosis, and these parts are accustomed to fight infection; they are used to the presence of septic organisms. So we saw at the last lecture that some of the most virulent infections, gas-gangrene and malignant edema were unknown about the face and jaws.

To consider then, specifically the injuries of this region. None call for a nicer application of surgical art. Underlying the soft parts of the face are large cavities; if their bony framework is shot away the flesh hangs unsupported as a loose mass of swollen and lacerated tags. As inflammation and swelling recede the flaps shrink into misshapen deformities, caricatures of the human features. The unfortunate wounded are pitied at first, even admired as heroes; they bear their scars with pride; as time goes on romance wears off, and the distorted features of the former hero are looked upon with horror and disgust; he shrinks from public gaze and ends, a recluse from human society. To prevent these deformities it is necessary that the wounded re-

ceive proper treatment early—very early. After the first day the loose flaps begin to swell with inflammation, later they shrink, either makes impossible the proper adjustment of the bony framework or its replacement, if necessary, by prosthetic appliances. The wounded should therefore be taken in hand as soon as possible after injury, before either swelling or shrinkage has begun, and it is greatly to the credit of dental surgeons that they have repeatedly insisted upon the recognition of the evils of delay.

The mortality of wounds of the face and jaws is not great. The principal dangers of gun-shot wounds are two: infection and hemorrhage. Sepsis we have seen, plays no great part in the injuries under consideration; hemorrhage, unless the carotid is wounded, is as a rule easy to staunch. If the carotid is cut, the bleeding is so severe that the wounded rarely reach hospital but usually die in the field. Now and then, however, the internal maxillary or some other large branch is slowly eroded and gives rise to a late hemorrhage so that a typical ligation of the carotid at the front edge of the sterno-cleido-mastoid may be called for. A transverse incision should be made at the level of the hyoid, the skin, superficial fascia and platysma divided, the sheath of the vessels opened, the jugular vein retracted to the outside, the external carotid freed and tied. As a temporary expedient against moderate bleeding from the nose the posterior nares may be plugged by inserting a rubber catheter thru the nostril into the pharynx, drawing it forward out of the mouth, tying a plug of gauze to it with a thread and drawing the plug back into the posterior nares; to try this method with a profuse hemorrhage is, however, to lose time.

Suffocation is another complicating emergency that is occasionally fatal unless quick aid be at hand. If the bony frame of the jaw be broken the asphyxia

may be due to a dropping back of the tongue into the gullet. The remedy lies in pulling the tongue forward and keeping it forward by a stitch passed deeply thru its tip. The stitch should be knotted loosely so that it may not cut thru, and may be fastened to a frame placed in front of the mouth. Another cause of asphyxia lies in edema of the glottis, especially with phlegmons of the floor of the mouth. A knife-thrust thru the skin and into the trachea and the insertion of a tube may save the man's life. These complications of injuries to the mouth and jaws are rapidly fatal unless relieved; but death is more frequently due to more slowly acting disturbances of respiration and deglutition. The men have a hard time swallowing; they are often utterly unable to spit out what gathers in their wound-cavities. They gag and choke over their food and aspirate their wound secretions into their lungs; death follows on aspiration-pneumonias, gangrene and abscesses of the lung. As with severe cases of carcinoma of the tongue it may be wise to do a prophylactic tracheotomy and even a gastrostomy; to insert a tube directly into the stomach thru which the wounded may be fed without disturbing the mouth.

If now we consider the injuries of the various regions of the face and jaws we have, as fundamentally different, lesions of the soft parts and of the bone.

Wounds of the soft parts alone are not often severe, except as the result of burns. Burns of the face may have serious sequels. Scars may shrink the eyelids so that the eyes remain uncovered and are made liable to ulcerations of the cornea and suppuration of the tear-ducts. Burns about the alae of the nose may narrow the nostril until nose-breathing is impossible, or may destroy the soft parts of the nose altogether and make the face a hideous mask. Burns of the ears are bad; the skin is thin, the cartilage is often laid bare. Infection follows, the ear swells to a huge size, like a prize-



fighter's cauliflower-ear, the cartilage becomes necrotic, swims in pus, and finally after repeated incision of abscesses comes out entirely. Then suppuration ceases. The swelling recedes, and the ear shrivels to a little misshapen button on the side of the head. Burns about the mouth and lips may narrow the mouth so that it cannot be opened enough to admit a

tissue in the neighborhood or a loss of tissue of the lip itself may pull down the mouth so as to expose the teeth and make what is left of the chin go over directly into the gums. The exposure of the teeth leads to dry and foul mouths and pyorrhea.

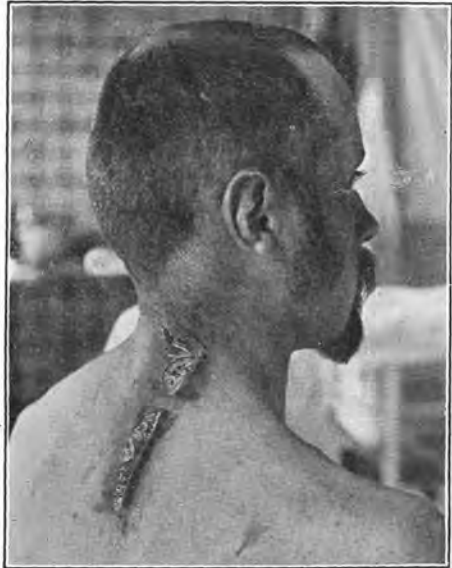
Methods for the correction of these deformities we shall discuss next time.

Figure 7.



Extensive burns of face and body from explosion of ammunition. Retraction of lower lip by scar with eversion of oral mucosa. Italian plastic, abdomen to wrist.

Figure 8.



Rifle bullet wound. Entrance at right zygoma, exit at nape of neck.

teaspoon, more often, however, the opposite effect is produced; the scar everts the lips, especially the lower one, which is most commonly affected. The skin of the chin shrinks, a broad strip of buccal mucosa shows at the lip, the lip is abnormally thick. At times it is so shrunk that the lower incisors show, and there is a constant drooling of saliva.

"Ambrine," the French patent preparation of wax and rosin has been greatly lauded as preventing scar shrinkage. I have had no personal experience with it.

Besides these burns, scars from loss of

It is not often that the soft parts are wounded without the bones being injured unless from a shot that just grazes the face. Glancing shots leave a burn rather than a wound, often with a considerable amount of scar and a deep brown pigmentation following. There is, however, one form of penetrating injury that leaves the bone uninjured,—a shot across the mouth and thru the cheeks. The tongue may be shot thru, often it is just grazed; it seems to have a faculty of getting out of the way. It swells greatly, the mouth is sore and the men have difficulty in speaking and swallowing for a week or

two, but the injury heals kindly. A curious form of this wound, puzzling to the uninitiated, is where the wound of exit is on the cheek and just one round wound is visible from the outside. If the man is told to open his mouth another small opening appears on the mucosa of the cheek. One wonders what became of the bullet. Has the fellow swallowed it? No;—he was shot thru the open mouth. The bullet entered the mouth and came out on the outside of the cheek. These wounds are not rare, they occur while the men are storming forward in a charge, yelling.

There remain to be considered the injuries where your dental services are most necessary, wounds of the bones of the face and jaws.

The bones of the face are thin and easily penetrated; a rifle ball will pierce them without shattering them much, but a fragment of shell may smash them out of all human semblance. The cavities of the face are frequently opened. Cracks and defects of the bones of the forehead may lead into and open the frontal sinus; the anterior and lateral wall of the antrum may be shot away, its top may be cracked so as to let the contents of the orbit drop, or the deeper cavities, the sphenoids and ethmoids may be opened. From the frontal sinus of one man I dug out about a teaspoonful of red French earth and rocks, another came into the hospital with a drain the size of your index finger sticking thru his cheek into the antrum, a third had a gunshot wound across the top of his face. About two weeks after injury this man began to complain of a loss of vision. His ethmoids and sphenoids had been opened, and the inflammation had spread to the optic nerve. Still another had a piece of shell traverse his brain and show at the base of the skull with the X-ray. An accurate localization placed it in the ethmoid. I entered the nose at the inner angle of the eye and drew out a fragment of steel the size of a lima bean.

These injuries lie above the level of the teeth; a shot lower down may fracture the maxilla in all possible ways. It may break the palatine plate off horizontally so that it will slide back and forth and sidewise; it may knock out half of the palate, or perhaps only the alveolar plate, it may crack it into small pieces or carry it away in part or as a

Figure 9.



X-ray, fragment of shell in cheek.

whole. It is best to mould the fractured bones into shape, if there are any left to mould, as soon as possible. A little anesthetic may be necessary; a quick ether narcosis with the cone is least harmful, altho no anesthetic is good for these men with mouths full of blood and dirt. The fracture may be held by a dental splint or temporarily by placing a wad of cotton under the upper teeth and tying the maxilla firmly into place with a bandage that passes over the top of the head. If the nose is intact gauze may be stuffed firmly into the floor of the nasal cavity. This, however, is a painful procedure and the gauze packing is most uncomfortable. I do not



know enough about the prosthetic treatment of these fractures to discuss them before this society of dentists, but I wish to repeat that obdurators and appliances for correcting deformity of the face and mouth resulting from loss of bone should be inserted promptly after the injury, soon enough to forestall shrinkage, and should put moderate tension upon the cheeks in order to prevent their falling in. Wounds of the outer plate of the maxilla and the antrum make a scar which draws down and everts the lower eyelid when it shrinks, and needs a plastic procedure for its correction.

Fragments of shell and even spent bullets may lodge in the cavities of the face or in the soft parts. Their removal is usually indicated; they tend to keep up supuration in the sinuses and they are not difficult to extract if properly located by the X-ray. The sinuses are entered by the usual route, the foreign body removed and the cavity drained. If the body is of steel or iron, (a shell fragment), a magnet may greatly facilitate its removal. Sometimes the bullet lodges in the body of the masseter or the pterygoids and keeps up an irritation and trismus until it is extracted; such a case may even be mistaken for tetanus. Extraction of a missile from the masseter is not difficult, but one lodged in the pterygoid may be very hard to get at. It should be accurately located by the X-ray and its position fixed by a needle led down to it under the guidance of a fluoroscope. It may then be withdrawn thru a trans-oral incision. The neighborhood of the internal maxillary makes the work risky; incision from the outside in back of the jaw is dangerous to the facial nerve.

Gunshot wounds of the mandible are quite different to those of the other bones. The jaw bone is denser and harder, it is more loosely articulated and more freely movable than the rest, and its fractures are always infected. It is so dense that it is usually completely

shattered or torn away if struck squarely by a bullet; instances where it is simply pierced by a long-range rifle shot are quite exceptional. Its hardness makes it break into numerous chips; it lies closely to the skin and if the chips are carried away by the force of the bullet great pieces of the soft parts are carried away with them and a vast defect is left. The whole chin, floor of the mouth and tongue may be torn away, and in the defect the open pharynx and a hopeless confusion of torn and mangled muscles be visible. The hemorrhage may not be great; an artery that is torn off does not bleed like one that is cut. Much loss of tissue and large defects in the soft parts of the mouth ensue even when the jaw bone is not shattered squarely across but only one-half of it is affected. An almost spent bullet, or a fragment of shell or shrapnel may of course, merely break the jaw from the force of its blow without shattering it, and make a fracture like those encountered in civil practice.

The condition of a man with a defect of the mandible like that described is deplorable. His cheeks soon swell enormously, he drools blood and saliva from his cavernous mouth, he cannot swallow foods or liquids, he cannot talk, the injuries are exceedingly painful. Fortunately most of these wounded, unless they have some complicating injury to the skull, are able to walk.

The rule for their treatment at the front is to get rid of them quickly; to evacuate them as soon as possible. They belong in a base or a home hospital under competent dental care. First treatment consists in cleaning the wound, which is usually wide open, of foreign material and dirt by irrigation with warm water or salt solution or boric acid. No bone should be removed unless it is entirely detached. If it hangs by even the loosest shred of periosteum, it should be kept. A part of it may become necrotic and be shed, most of it will live

and remain; it is surprising how little of an apparently loose piece of bone is lost—often nothing more than a thin flake from the exposed surface. A dental splint or some other fixation apparatus should keep the fragments in place. Captain Marshall will discuss this in a subsequent lecture. If trained dental help cannot be secured, the lower teeth may be wired to the upper ones.

It may be well to treat these fractures on the principle that joints should be treated in that position which is subsequently the most difficult to attain. Muscular contractures and trismus may be forestalled, therefore, by treating the fracture with the mouth open.

The soft parts should be as carefully preserved as the bone. They are well nourished, necrosis and sloughing are usually inconsiderable, and all that we can save is of value in getting a covering for the mouth and saving material for future plastics. Loose flaps and tabs may be stitched into place by one or two sutures or held by a piece of plaster. The wound should never be tightly closed nor even accurately approximated. The secretions should flow out freely. One should be especially sparing of the mucosa of the mouth; wherever possible it should be laid between the bone and the cheek in order to keep as much as one can of the buccal fold, whose preservation is the best means of preventing shrinkage and of keeping the soft parts loose from the bone for use in future plastics.

The men should be fed thru a tube.

This may be introduced into the gullet or stomach thru the nose; a better way is to give the man a nozzle cup with 10 or 12 inches of soft rubber tubing attached to the nozzle. By patient trial and with the aid and encouragement of a good nurse or surgeon he will soon learn to lead the tube into the esophagus thru the wound and to let fluids trickle down into the stomach if he cannot be made to swallow them actively. A nourishing mixture consists of a pint of milk, a tablespoonful of butter, one of sugar, two eggs, an ounce of whiskey and a pinch of salt warmed slightly and mixed, not beaten or whipped. After taking this mixture the mouth should be irrigated with water in order to clean it of milk, which curdles and sours in the wound. Long continuous irrigation with warm salt solution helps to keep the wound clean afterward. Sepsis, osteomyelitis of the jaw, phlegmon of the submaxillary space or of the neck may follow—sequels which we discussed last time. They are rare, rarer than one would think, judging from the irregular surface and infection of the wound.

Injuries of the face and jaws are not to be counted among the gravest of war, but there are none that better reward proper treatment and none that more heavily avenge neglect. If the face is allowed to collapse, and the defects in the chin to shrink the resulting deformity is most difficult to correct; ankylosis of the jaws, retreating chins, misshapen dentures are conditions whose relief I hope to be able to discuss before you next week.