DR. A. P. MERRILL, Pittsfield: I would like to ask Major Cotton a question. Do you first sterilize these cases by pure carbolic and alcohol? If so, does that not form a film of cauterized bone tissue through which the new bone tissue has got to work? Do you rely on the throwing out of bone tissue at the edge, or does it come also through this film of cauterized bone?

DR. FREDERIC J. COTTON (answering Dr. Lincoln Davis): I think the original scheme, as Dr. Goldthwait knows, was to use it as a substitute for bone, to pack up cavities which are left with wax in them, just as the fatty transplants. That did not work out very well. It never worked out with me. For a good many years I have used bone wax on the basis that it would be eventually extruded. It is gradually pushed out of the wound, and it leaves behind it a bed of granulation tissue, so that eventually you get your bone filling in. I have no right to say that the granulation tissue is necessarily osteoid. The cavity, when the thing was entirely healed, did not show lime salts by x-ray. Calcification of the whole cavity perhaps was never completed.

I do not feel that I want to use this method where there is not a sufficient cross section area outside to carry the weight. But on the whole, it represents simply a more certain and very much more comfortable way of doing things in this very selected and rather narrow type of case. The process is one that really belongs to chronic osteomyelitis rather than in these war cases.

DR. FREDERIC J. COTTON (answering Dr. Merrill): I pay no attention to the periosteum at all. I do not think there is any doubt but that you get a thin film of cauterized bone after you have sterilized. You put in crude carbolic for one and a half to two minutes by the watch. It is a question of not being afraid of carbolic, and you get a very easily demonstrated film on your soft parts. What does happen is that the granulation tissue goes up through that film, and it doesn't make any difference.

DR. COTTON (closing the discussion): I will just say in closing that we were working in a "repair-shop" hospital to clean up the cases, and had nothing to do with the battle-front work. There was perfectly wonderful work done there in the salvage cases. Ours were very late cases, and represented a practically definite, limited class of cases. I have presented them, not because they represent such a large share of the war work, but because they are very closely parallel to the civil problems. We do get a lot of these same cases in civil practice, which we happened to have the opportunity to familiarize ourselves with under war conditions.

A METHOD FOR MORE ACCURATE STUDY OF INJURIES TO THE ATLAS AND AXIS.

BY ARIAL W. GEORGE, M.D., BOSTON.

The following study of injuries to the atlas and axis, and the didactic method used, is the result of instructing medical officers for x-ray service at the Medical Officers' Training Camp, Fort Riley, Kansas, where it was found necessary intensively, and in the shortest possible time, to review the cervical region as well as all other parts of the body.

It was found in the beginning that the mere demonstration of x-ray plates did not suffice to make any very permanent impression upon the students and that their learning became a matter of mere imitation and was soon forgotten.

As the various classes came through the school, the method about to be described gradually unfolded itself. The principal object of this method is to leave with the students some fundamental facts: 1st, the study of the anatomy; 2nd, the variations from the normal.

The writer claims no special originality for the method and is indebted to the medical officers who were students and to the various instructors who throughout the time the school was in operation helped teach and suggest better methods of teaching. I am particularly indebted to Lieut. Harold Swanberg of Chicago, Ill., for his help on the subject.

NORMAL ROENTGEN ANATOMY OF UPPER CERVICAL REGION.

1. *Lateral View.* Before an interpretation can be made of the upper cervical region one must determine that the plate under examination has been taken in a true lateral position (See technique). This can best be determined by the position of the rami of the mandible. It is not possible exactly to superimpose the rami, though there should never be more than one centimeter's difference between the two. (See Figure 1, not a true lateral; Figure 2, a true lateral.)

In the true lateral position, an imaginary vertical line can be drawn along the anterior surface of the bodies of the cervical vertebrae (See line AB, Figure 3): also a similar line can be drawn, parallel to this line, along the posterior surface of the cervical bodies. (See line CD, Figure 3.) While these lines will not

hold good for the entire cervical region, for the purpose of diagnosis they are essentially true for the upper cervical region. In well developed male subjects, the anterior tubercle on the anterior arch of the atlas is frequently quite large and will project slightly anterior to the line drawn along the anterior cervical bodies. An imaginary line can also be drawn from the superior border of the anterior tubercle of the atlas to the superior border of the posterior tubercle. (See line EF, Figure 3.) It will be approximately parallel to a similar line drawn from the inferior border of the anterior tubercle to the inferior border of the posterior tubercle. (See line GH, Figure 3.)

Within the rectangle formed by lines AB, CD, EF, and GH (Figure 3), there is normally noted an increased density of bony structure. This is due to the fact that the lateral masses and transverse processes of the atlas, and the odontoid process of the axis are superimposed, and all lie within this area.

The area within the parallel lines EF and GH (Figure 3), posterior to the rectangle above mentioned, comprises the posterior extremities of the lateral masses and the posterior arch of the atlas, including the posterior tubercle. The relation of the posterior tubercle to the base of the skull varies, rarely being more than one centimeter from the base of the skull, except in congenital malformation. In a true lateral view each side of the posterior arch of the atlas should appear superimposed. If both sides of the posterior arch can be directly seen (Figure 3-B), it is positive proof that the atlas was not taken in a true lateral position, and without other sufficient evidence, injury is not to be considered. The posterior part of the posterior arch appears to project slightly upward. This is due to the fact that the anterior part of this same arch is flattened from above downward, due to the groove for the vertebral artery. (See congenital malformations.)

The posterior tubercle of the atlas is on a more anterior plane than the posterior extremity of the spinous process of the axis, but the anterior part of the posterior tubercle is never normally on a more anterior plane than the anterior part of the spinous process of the axis. This is due to the fact that the vertebral foramen of the atlas is larger than the corresponding foramen of the axis. (See Figure 3-C.)

The only apparent exception to this will be the congenital malformations of the atlas. (See congenital malformations.)

The retro-pharyngeal structures form a vertical line parallel to the anterior aspect of the cervical bodies. The uniformly dark area anterior to this represents the lumen of the pharynx.

An imaginary line can be drawn from the lower border of the body of the axis to the lower border of the spinous process of the same vertebra. (See line JK, Figure 3.) It is approximately parallel to the line drawn from the lower border of the anterior tubercle of the atlas to the lower border of the posterior tubercle. (Line GH.) In the rectangular space above the line JK, is the greatest part of the axis. The upper half of this area shows an increase in density of bone due to the lower part of the lateral masses of the atlas, the superior articular processes, body, and part of the odontoid process of the axis. The lower half of this rectangular space shows the body and transverse processes of the axis superimposed. The area posterior to the above rectangle, and between the lines GH and JK, contains the inferior articular processes, laminae and spinous process of the axis.

Normally there is no break in continuity in the upper and lower borders of the laminae of the axis. The anterior portion of the spinous process of the axis is always on a more anterior plane than the anterior part of the posterior tubercle of the atlas.

2. *Antero-Posterior View.* In an antero-posterior view of the upper cervical region, imaginary vertical lines can be drawn from the lateral and median margins of the lateral masses of the atlas (See lines LM, NO, PQ, and RS, Figure 4), passing through the lateral and medial margins of the superior articular processes of the axis and are approximately equally distant apart. The odontoid process appears in the central portion of the two median lines.

The hyaline cartilage on the inferior articular surface of the lateral mass of the atlas and the superior articular surface of the axis is of uniform thickness on each side, thus resulting in an apparent clear space on each side, since they offer no obstruction to the roentgen ray. The posterior arch can be recognized by a continuation of the shadow of the arch with the trans-

verse processes, and as it is in closer proximation to the plate than the anterior arch, it is more clearly seen on the plate. The anterior arch may be occasionally recognized, and can be demonstrated by its conjunction with the spongy bone comprising the lateral masses (See Figure 4-B). In the average case the apex of the odontoid process projects just above the shadows produced by the arches. From the roentgen standpoint, the superior articular surfaces of the axis are more or less flattened, or even slightly concave, and the inferior articular surfaces of the atlas are slightly concave. The body of the axis is of uniform density and structure, excepting in the median line, where we can sometimes see the shadow of the bifid spinous process of this vertebra.

PATHOLOGIC ROENTGEN ANATOMY OF UPPER CERVICAL REGION.

1. *Lateral View.* One of the most important observations that can be made of the pathology of the osseous system is the loss of the normal curves by the formation of acute angles. Injuries, destructive bone diseases, etc., will be early recognized by the formation of these angles (See Figure 6): this is particularly true of the vertebral column. In the interpretation of injuries and diseases, the value of the imaginary lines as mentioned above becomes of utmost importance, *e.g.*,—in one of the most frequent injuries of the atlas, forward dislocation of the head and atlas upon the axis, the following points are to be noted: First, that the line AB (Figure 5) will be no longer parallel to the line CD, and if extended would very soon meet. The vertical line produced by the retro-pharyngeal structures anterior to the anterior tubercle of the atlas will be distorted. The lines EF and GH will remain parallel, and the normal distance apart, but occasionally more of the lateral masses may be demonstrated on the plate. This observation must be kept in mind so that it is not confused with the production of new bony tissue in this region. The length of the posterior arch and tubercle behind the line CD is very much shortened. The anterior margin of the posterior tubercle will also be seen on a plane anterior to the anterior margin of the spinous process of the axis. Occasionally a fracture of the odontoid process can be recognized in the lateral position, but it is usually seen better in the antero-posterior view.

In Figure 7 will be noted that the vertical lines AB and CD do not continue along the anterior and posterior surfaces of the cervical bodies, being suddenly interrupted at the third cervical vertebra. The line formed by the retro-pharyngeal structures is also interrupted in the same area. Nothing can produce this change, except a forward dislocation of the skull, atlas, and axis of the third cervical vertebra. It will also be noticed that the anterior part of the posterior tubercle is on a more anterior plane than the anterior part of the spinous process of the axis, which is not normal. However, the relation of the remaining parts of the atlas and axis to each other is normal. Naturally one will wonder what condition can produce such a change. A careful examination of the laminae of the axis will reveal a break in continuity,—a positive diagnosis of a fracture. This readily accounts for the distorted relation of the posterior tubercle to the spinous process of this vertebra.

In Figures 8 and 8-A will be noted that the vertical lines AB and CD do not continue along the cervical bodies, being interrupted, as is also the line produced by the retro-pharyngeal structures. A diagnosis of anterior dislocation of the skull and atlas on the axis can readily be made. However, the outline normally formed by the body of the axis is distorted, and shows considerable less density than normal, which is diagnostic of a pathologic change in this body, which in this case is metastatic carcinoma. In the original plates it can be seen that the odontoid process has separated from the body of the axis and is in contact with the anterior arch of the atlas.

2. *Antero-Posterior View.* In Figure 9 it will be noted that the imaginary lines LM, NO, PQ, and RS, extending from the lateral and medial margins of the lateral masses, do not pass through the lateral and medial margins of the superior articular processes of the axis. The two lateral lines do not touch the axis at all, while the median lines pass through the center of the superior articular processes. The space between the two median lines is also much larger than normal. There is no position in which the normal head can be placed to secure this result. The only thing possible that will do this is a fracture of the anterior and possibly posterior arch of the atlas, thereby separating the lateral masses.

Dislocation, without fracture of the atlas, will

always obliterate the normal articular space between the inferior articular surface of the lateral mass of the atlas and the superior articular process on the side of the dislocation, or both sides. (See Figure 11.) There is no possible position in which the normal head can be placed to obliterate the normal articular space mentioned above.

Congenital Malformations of Upper Cervical Region.

The most important congenital malformation in the upper cervical vertebrae from the roentgen viewpoint is that of the posterior arch of the atlas. Comparatively frequently a bony spiculum is seen which arches backward from the posterior extremity of the superior articular process of the atlas to the posterior arch, converting the vertebral groove into a foramen, through which the vertebral artery passes. (See Figures 12, 13, 14.) This foramen should not be confused with an area due to destructive bone pathology.

ROENTGEN TECHNIC OF UPPER CERVICAL REGION.

1. *Lateral View.* The patient is placed in the prone position with the head resting on the table, the face being directed upward, parallel to the table. In this position a line perpendicular to the table can be drawn from the lower border of the upper incisor teeth to the tip of the mastoid process. If a lateral view of the entire cervical region is desired, the shoulders are forced downward as far as possible and a plate is placed on the lateral side of the neck, pressing down on the shoulder. The plate is held in (Figures A and B) position by a headrest, sand bags, etc. The tube is tilted on its side, a small diaphragm, together with a small cone, being used. The central ray is centred immediately posterior to the ramus of the mandible.

Another position which will give the same results is obtained by having the patient sit in a chair with the tube tilted on its side. The plate is held by an assistant against the neck.

2. *Antero-Posterior View.* In the ordinary antero-posterior view of the cervical region the upper two or three cervical vertebrae will not be seen, on account of the location of the mandible anterior to these vertebrae. In order to obtain an antero-posterior view of the atlas and axis it is necessary to place the patient on the table in a manner similar to that necessary for

a lateral view, *viz.*, prone position with head on table, face directed upward, parallel to table. The mouth is opened to its greatest extent, a cork being placed between the teeth to maintain this position, and a plate is placed well up under the occiput. A small diaphragm, together with a small cone, is used, the central ray being centered over the center of the open mouth.

DISCUSSION.

DR. S. W. ELLSWORTH, Boston: I feel that we are under obligation to Dr. George for describing a very simple and useful method of studying such a difficult part of the skeleton as the cervical spine. In the plates ordinarily taken of this part, the bony outlines are very indistinct; with the aid of the parallel lines, however, one should be enabled to study abnormalities of position or outline with greater accuracy.

Anomalies of the atlas occur more commonly than is generally supposed; they will be frequently found if searched for and should not be confused with traumatic deformities.

I have here as an example of the anomaly of the posterior foramina, the atlas from a skeleton which we have used in the study of x-ray plates, which shows the arches behind the articular facets.

This paper illustrates again the fact that we must review our anatomy repeatedly; careful study with the aid of the x-ray plates will show many new and novel conditions.

DR. G. W. HOLMES, Boston: I think we ought to thank Dr. George for giving us some help on a most difficult part of the anatomy to study with the x-rays.

It is of greatest importance to have an established normal in mind before attempting to interest the pathological. There are a great many things which may cause the normal to look abnormal. Even if particular care is taken in placing the patient, it is perfectly possible to have very abnormal pictures. It is a great help to have a definite standard in mind.

In regard to the question of using this method for teaching, I would say it would depend largely upon the class of students being taught. If you are teaching radiologists it would certainly be a good guide. But in teaching undergraduate students of medicine I should bring out a little more the clinical side. These students do not have a sufficient knowledge of x-ray interpretation to rely wholly upon the x-ray findings. It is much better, as a rule, for the student to keep in mind his clinical evidence, and I should try to impress upon him that if he has a picture which to him seems to be abnormal, his diagnosis ought to hinge more on the clinical findings than on the x-ray.