Necropsy on two of these cases showed, so far as the field of operation was concerned, a complete fusion of laminae and spinous processes from the lateral articulation on one side to the lateral articulation on the other side, the fusing bone mass in both instances being thick, strong and efficient, thereby proving that the operation itself had been perfectly successful.

In the four cases referred to in which reoperation was required, because an insufficient number of vertebrae had been included in the original operation, an incision was made through the old scar, the original field of operation was exposed, and the vertebral fusion present was found complete, but too short. After healthy vertebrae were included both above and below, the results were as satisfactory as in the other cases. The bone production is easily demonstrated by Roentgen ray in most cases, but the chief value of the roentgenograms is as a preoperative guide to indicate the number of vertebrae which should be fused.

The experimental series may be classified as follows:

Dog No.	Date of Operation	Date and Cause of Death	Days Old
172	March 23	March 27, meningitis	4
178	March 25	March 27, shock?	2
177	March 24	March 31, meningitis	7
126	March 22	March 25, shock?	3
127	March 22	March 28, meningitis	6
188	April 1	April 10, meningitis	9
189	April 1	Still living	
175	March 24	March 27, nephritis	3
194	February 5	Still living	
167	March 20	Still living	
166	March 20	Still living	

From the above it appears that the majority of the dogs died either of meningitis or shock. One, however, died of unilateral nephritis, based on autopsy finding.

It is interesting to notice the wide difference in mortality rate between the animal and the human series. For seven dogs the average postoperative life was four and one-half days; the total mortality, in a series of eleven dogs being 72.7 per cent. The cause of this high mortality has not yet been worked out, but as, with two exceptions, the skin wounds healed primarily, the inference is that the operative technic was reasonably clean and that dogs tolerate operative procedure of this nature poorly.

Of the recovered dogs, subjected to euthanasia, two, respectively sixty-two and sixty-eight days postoperative, show that while sufficient bone growth had not taken place to fuse the bridged vertebrae, considerable bone was shown in process of formation. Furthermore, these were undergraduate student preparations in which the fragments were found not to have adhered in a position to insure early fusion of the joints. It may be further noted that lamina-fusion in these animals was not attempted, nor were the lateral articulations disturbed, because of an attempt to reduce the mortality by using a less extensive procedure.

Another specimen, eighty-five days postoperative, shows complete vertebral fusion, while in another, over 100 days, somewhat denser bone deposits exist. One may therefore conclude from animal experiments that osteoplastic operations on the spine of dogs, especially if the laminae and lateral articulations are disturbed, is attended with high mortality, and that terminal bone formation sufficient to fuse the vertebrae and destroy all motion does not occur until after the seventy-fifth day.

Good Legislation.—It is the duty of the government so to legislate as to make it easy to do right and difficult to do wrong.—*Gladstone.*

OBSERVATIONS ON BONE TRANS- PLANTATION (ALBEE METHOD) FOR THE CURE OF TUBER- CULOUS SPINE DISEASE*

CHARLES M. JACOBS, M.D.

Associate Clinical Professor of Orthopedic Surgery, University of Illinois Medical School; Attending Orthopedic Surgeon, Cook County Hospital and Home for Destitute Crippled Children

CHICAGO

Certain principles in the treatment of tuberculous spine disease appear so firmly established that they have been regarded as axiomatic. For 135 years conservatism has been considered the only reasonable and safe course to pursue, whereas it is only recently that operative measures have come into their own in Pott's disease. Hence to replace conservative by operative measures is to run counter to the established conservatism in the treatment of the disease, and naturally there is opposition on the part of those who have not yet accepted radical measures.

In considering the possibilities of cure for Pott's disease by bone transplantation into the split spines of several contiguous vertebrae, or by any other operative method, clinical experience is necessary to form an unbiased opinion of its practical value. At the last session of the American Medical Association a paper was presented by the surgeon in charge of the Sea Breeze Hospital, giving his interpretation of the results of fifteen cases of tuberculous spine disease in which operation was performed by the originator of the Albee method at the above-mentioned institution. The report was extremely unfavorable, and the publication of which leads me to present my observations with the hope that other men of experience may carry the discussion farther, thus adding light on a subject of so much importance.

Unquestionably bone transplantation, as advised by Albee, marks a new epoch in the treatment of Pott's disease and is a valuable surgical asset. Surgery shows to better advantage here than in tuberculous joints elsewhere in the body; there is no danger of disseminating the infection into contiguous normal bone; no sacrifice of bone to affect shortening and it is in accordance with orthopedic principles in securing physiologic rest, thereby affecting the pathologic process.

Let it be understood that I do not favor surgical measures in every case of Pott's disease. The value of any plan of treatment in tuberculous spine disease is estimated by its effectiveness in combating ultimate deformity. Under conservative treatment recovery may be anticipated, in an average period of three or four years, with or without deformity, depending often on the region of the spine affected. We know that caries in the middle and upper dorsal region of the spine is frequently associated with great angular protrusion, whereas caries in the cervical or lumbar region, even when extensive, has little or no kyphosis. This is explainable by the fact that the superincumbent weight is greatest on the bodies of the vertebrae in the dorsal region because of the normal curve of the spine being concave in front. In childhood, therefore, routine treatment should be protective except, perhaps, in middle and upper dorsal Pott's disease; but in cases in which conservative treatment has been tried

* Read before the Section on Orthopedic Surgery at the Sixty-Fifth Annual Session of the American Medical Association, Atlantic City, N. J., June, 1914.

and found impossible to control, surgical intervention is then justifiable. In adults operative measures depend on social and economic conditions. The leisure class is in a position to choose between conservative and operative treatment. On the other hand, the wage earner must regain health in the shortest possible time; therefore, conservative treatment in his case demands a sacrifice justified only by a necessity which I consider no longer exists.

Undoubtedly surgical measures in Pott's disease shorten the period of disability with a presumption of a rapid cure. But rapid cure, in the exact sense, cannot be obtained by any method of treatment in tuberculous spine disease. In comparison to conservative methods, bone transplantation followed by protective treatment shortens the duration of tuberculous spine disease many months. The early relief afforded patients from discomfort and pain following the operation is striking.

It is needless to state that bone transplantation has no direct curative action on the tuberculous process.

Bone transplant extending from first lumbar vertebra to coccyx; bodies of the fourth and fifth lumbar vertebrae destroyed.

The underlying principle is fixation of the vertebrae in order to hold the spine in the extended position so that pressure on the diseased area may be removed, thus arresting and controlling the morbid process. Success thus depends on the efficiency in which the spine is splinted. This is accomplished, primarily, by the bone graft being implanted into the spinous processes of all the diseased vertebrae and at least two contiguous vertebrae on either side. This will effectively splint the spine. A source of failure is almost invariably due to the error of implanting the graft into the contiguous vertebrae of one end only which imperfectly eliminates motion. To obviate this error it is all important that the extent of the diseased area be accurately determined by a good roentgenogram before proceeding to operation. The kyphos alone is not a sufficient guide.

External support, either casts or braces, must not be disregarded for many months following the postopera-

RESULTS OF OPERATION IN NINE CASES OF POTT'S DISEASE

Case	Duration of Disease, Years	Deformity Previous to Operation	Age at Time of Operation, Years	Vertebrae Affected as Shown by X-Ray	Reasons for Operation	Date of Operation	Location of Graft as Shown by X-Ray	Length of Time of Post-operative Recumbency, Months	Length of Time of Post-operative Protective Treatment, Months	Ultimate Results
1.....	2½	Yes	13	3 to 4 L.	Increasing kyphos	4/13	1 to 5 Lumbar	3	3½	Has no discomfort or pain; lower end of graft stands out prominently; right lateral curve of the spine above the graft.
2.....	3	Marked	5	3 to 4 D.	Discomfort and pain on walking	7/13	2 to 5 Dorsal	1½	3	No discomfort nor pain, and walks with ease; kyphos slightly increased.
3.....	?	Yes	19	7 to 10 D.	Economic Pain on walking; discharging sinus.	8/13	5 to 12 Dorsal	2	None	Without symptoms; no increased kyphos.
4.....	4	No	7	4 to 5 L.	Economic Pain on walking; discharging sinus.	9/13	1 to 5 Lumbar	2	None	Walks with ease and is without symptoms other than sinus has not closed.
5.....	2½	Marked	7	11 to 12 D.	Grunting; respiration; increasing kyphos	9/13	9 D. to 3 L.	2	3	Allowed up without any protection, but after one week a cast was applied because of grunting respiration; after three months cast was removed, since which the kyphos has only slightly increased; otherwise without symptoms.
*6.....	3	Yes	6	7 and 8 D.	?	4/13	7, 8, 9 D.	2½	None	Four months after operation unable to walk and was placed on Bradford frame.
7.....	½	Slight	20	11 to 12 D.	Discomfort and pain	12/13	10 D. to 5 L.	1½	None	After six weeks, protective treatment became necessary because of a "slight weakness" referred to the abdomen; two months later the cast was removed, and the patient has been without symptoms; no increased kyphos.
8.....	1	Yes	32	12 D. to 2 L.	Economic	12/13	10 D. to 4 L.	6	None	Graft became infected and was removed; Roentgen-ray shows beginning bone formation connecting spinous processes.
*9.....	3½	Slight	18	6 to 10 D.	Pressure paralysis	3/13	6 to 12 D.	3	1½	Without symptoms for six months following operation; then right knee gradually began to "jerk," and unable to walk; patella defects and ankle-clonus much increased; now on Bradford frame.

* Operated on before coming under observation of the author.

tive period of recumbency (six weeks), inasmuch as too early reliance cannot be placed on the strength of the graft. It is improbable that a firm bony union exists between the graft and the split spinous processes in this period of time. Albee, however, states that the graft becomes united by bony union in four weeks. According to Dupuytren and Wieder, there is no permanent callus formation between the ends of the transplant and the bone into which it is to be transplanted before the eighty-fifth to two hundred and fiftieth day.

In the middle and upper dorsal region of the spine, where deformity has developed necessitating a pronounced bending of the bone insert, the strain on the graft is greatest. Unless external support be given, tracings of the spine will almost invariably show an increased, rounded kyphos. In lower dorsal or lumbar Pott's disease the graft is usually straight and the strain is mostly confined to its lower end. Here again it is necessary to use external support; otherwise the lower part of the graft may not remain firmly anchored and then it stands out prominently. I am accustomed to give postoperative protective treatment at least for six months. Clinically no harm can come from too long a protection—other views notwithstanding.

This paper is based on nine cases observed in my private practice and on my services at the Cook County Hospital and the Home for Destitute Crippled Children during the year of 1913. In seven of the cases operation was performed by me and in two (Cases 6 and 9) by other surgeons. No attempt has been made to gather cases for statistics from other sources.

CONCLUSIONS

I feel warranted in stating that:

1. Surgical measures for tuberculous spine disease are a great advance over conservative treatment, but should be restricted to selected cases. Undoubtedly they shorten the period of disability.
2. Not only may existing deformity be prevented from becoming exaggerated, but also deformity itself may be prevented by surgical measures.
3. Too early reliance cannot be placed on the strength of the bone graft. It takes time for the splint to become securely fixed by permanent callus.
4. External support must not be disregarded for many months following the operation; otherwise deformity may ultimately occur.
5. Even with postoperative protective treatment for a period of six or more months, the duration of treatment is much shorter than the average duration under non-operative methods.
6. Success of bone transplantation for the cure of tuberculous spine disease depends on the proper implantation of the bone splint into the diseased and normal contiguous vertebrae. Essential to the success is the *careful protective after-treatment* for a period of months.

I wish to thank Mr. Julius Gillis, private radiologist, and Dr. Edward S. Blaine, radiologist at Cook County Hospital, for their valuable aid with roentgenograms.

ABSTRACT OF DISCUSSION

ON PAPERS OF DRS. FARRELL AND JACOBS

DR. W. G. STERN, Cleveland: One question cannot be settled by animal experiments, but only by long clinical experience, and that is, can the bones of one human being be permanently transplanted into another? If the bones of

one individual can successfully be transplanted to another, we have before us a means of making transplants of even greater extent and scope than the ones already shown. Hoffmeister, in Germany, for sarcoma of the upper end of the humerus, took the fibula of a cadaver and using the external malleolus as the joint-forming body, implanted the other end into the shaft of the humerus. He was able, by means of this long piece of bone, to put the muscles of the arm under great tension; and the result was eminently successful. Reports have been drifting to America, brought by word of mouth, that some of these splendid operations, done by means of transplants from one individual to another, have not been permanently successful. The bones, which apparently healed in and formed a new joint in Lexer's case, later lost their bony character, and after a year or two, could no longer be identified as bone. If this transplantation from one individual to another will succeed, the method offers a promising field in the large hospitals, from material gathered in cases of amputation, etc. I also agree that in the operation of transplantation for the cure of Pott's disease, the graft should extend a fairly long distance above and below the seat of the disease; and that the case should have mechanical support for a long time afterward.

DR. JOHN B. MURPHY, Chicago: It is pleasing to note that the position that we have taken is being confirmed, that a bone of any size, even to that of the longest bone of the anatomy, can be transplanted from one part of an individual to another part and will survive if it be aseptic. The question is not yet settled whether the periosteum and the compact bony tissue or the medulla plays the most important rôle in the regeneration of bone. It is fairly well established that the autotransplant gives the best results. In something over one hundred cases of bone transplants of all sizes, from 14 inches down, we have removed only one transplant. This shows the uniformity with which bone can be healed in. It matters little whether the bone is placed on the surface, in the compact bony tissue, or in the medulla. What we are interested in, and where we feel that work can be done by this section, is in the treatment of malignant and semi-malignant lesions of bone by resections in place of amputations. Our great work is going to be that we shall be able to prevent metastasis by early resection of bone and save the extremity. The epiphyses must be preserved when this can be done, because they are important for the growth of bone. That we are not doing for tuberculosis in all portions of the body the best that we can, is definitely settled in my mind. We must do more than merely give mechanical support. Great stress has been laid on the advisability of keeping a patient with tuberculosis in activity. I consider that an error; for it lessens the opsonic index in the extremity as well as in the lung. How well satisfied are we with the management of our cases of tuberculosis of the hip on the former orthopedic basis of mobility?

DR. JOEL E. GOLDTHWAIT, Boston: The discussion has shown that bone transplants can be inserted in large pieces and that they will not be thrown off. Conservatism in the treatment of malignant bone and joint disease promises, certainly, as much as any other; because Coley's statistics reported a short time ago, showed that life was not prolonged by operation. The disease goes on, in spite of such radical measures. This method of bone transplantation offers an opportunity to do something early, when the patient is willing.

DR. M. S. HENDERSON, Rochester, Minn.: I have operated on five patients by Hibbs' method. Clinically, ankylosis was obtained. The most striking case was that of a young man 25 years of age who had a lumbar Pott's with large psoas abscess, but no sinus. After operation the abscess was aspirated, the patient gained 35 pounds and manual labor was resumed. Later he developed acute miliar tuberculosis of the lungs and died. Three other patients were apparently cured. One is too recent to report. I have operated in over thirty cases by the Albee method. We lost no transplants. In those observed long enough after operation to be fair, it would seem that ankylosis was secured. Dr. Murphy emphasizes the practicability of bone transplantation. In something over seventy transplantations we have only lost one graft.