EXPERIMENTAL SCOLIOSIS IN PRIMATES
FAILURE OF A TECHNIQUE

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An attempt to produce scoliosis in young baboons by excision of the heads of ribs failed in thirteen growing animals observed for up to a year after operation. Other investigators have failed to produce scoliosis in primates by similar and other techniques that had successfully produced scoliosis in quadruped animals. The possible reasons for this are discussed, especially in the light of clinical trials that are being carried out with techniques transposed from the quadruped experimental animal to the scoliosis clinic.

An experimental model, on which the theories and practice of scoliosis may be tried out, is still one of the major needs of orthopaedic surgery. Many attempts have been made to produce in the laboratory animal a spinal curvature that resembles that seen in clinical practice. A valuable summary of these attempts was presented by MacEwen (1973). The few successes have, in general, been of little value either in explaining the pathogenesis of human deformity or in affording a model on which new therapeutic techniques could be devised and attempted. Langenskiöld and Michelsson (1962) described a technique of excision of rib heads in rabbits, which they claimed was effective in producing a spinal curvature. The deformity progressed in severity with growth and could be arrested by performing the same operation on the other side within a short space of time. Other investigators repeated this work (Manning 1968, Piggott 1968) and were sufficiently impressed by the consistency of experimental success to adapt the technique to clinical practice. Both Piggott (1971) and Manning (1973) reported the use of rib head excision as a technique aimed at halting or at least delaying the progress of infantile idiopathic scoliosis in young patients. The results have not, however, been completely convincing.

In a previous experimental study (Robin 1966) intercostal paralysis was produced in young dogs. In spite of the fact that such paralysis has been recognised as a factor

Fig. 1
The articulated spine of the baboon (Papio papio) viewed from the back. There are eight lumbar and twelve thoracic vertebrae. The resemblance to the human spine is obvious.

Fig. 2
The seventh thoracic vertebra of an adult human female (left) and a young baboon male (right) viewed from below. The baboon vertebra has the proximal end of the left rib still attached. Apart from the angulation of the transverse processes, the baboon vertebra looks like a reduced copy of the human one.

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in the pathogenesis of paralytic scoliosis in poliomyelitis, significant spinal deformity could not be produced. It was thought that the lack of axial gravitational stresses on the spine of the quadruped animal might explain this experimental failure.

It was decided therefore that it would be worth while to adapt Langenskiöld’s technique to primate animals to show whether the gravitational effects of the erect posture would aid in producing a spinal deformity that resembled that seen in idiopathic scoliosis. The operative procedure was aimed at producing scoliosis without a direct attack on the vertebrae, without interfering with muscle balance in the region, and in an animal that spends a considerable part of the day sitting upright or walking in the semi-erect position. Moreover, the experiment was to be carried out on an animal whose vertebral column closely resembles that of the human, except for the number of segments in the different areas (Figs. 1 and 2).

**TECHNIQUE**

Thirteen baboons (*Papio papio* and *Papio hamadryas*) were used in the experiments. The first three animals were aged approximately one to two years and weighed between nine and thirteen kilograms. Failure to produce any scoliosis in these animals over a period of several months, in spite of continued growth evidenced by weight increase of from five to nine kilograms, led us to use much younger animals, with a greater growth potential, in the remaining experiments. Ten additional baboons were therefore used, aged from two to three months and weighing on average three kilograms. The operation involved a fairly long incision, dissection through several layers of muscle and resection of four to five rib heads. The danger of damaging the pleura and producing pneumothorax in the experimental animal was not small. The complex anaesthetic technique (Aronson, Robin, Weinberg and Nathan 1965) developed in our laboratory for baboons ten years ago was used only in the first experiment, the availability of the new tranquilliser drugs that act specifically on primates making the remaining anaesthetics much simpler (Moor-Jankowski and Rodriguez 1963).

Thirty minutes before operation the animals were given an intravenous injection of “Sernylan” (phencyclidine) in a dose of 1 milligram/kilogram. This induced a state of sleep that allowed transfer of the animal to the operating room, positioning on the table, insertion of an intravenous infusion, and shaving and preparation of the operation area. An intravenous dose of pentobarbitone, 5 milligrams/kilogram, was then administered. This induced surgical anaesthesia with little respiratory depression. Routine ventilation was found unnecessary although a simple oxygen ventilator with a face mask was available. Endotracheal intubation was not required. Additional small doses of pentobarbitone were added as required during the course of the operation.

A paravertebral incision was made in the thoracic area, about 2 centimetres from the midline. The large trapezius muscle was reflected laterally from the median raphe, exposing the paravertebral muscle mass. An incision through the fascia at the lateral border of the erector spinae allowed medial reflection of this muscle and detachment from the transverse processes while preserving its segmental nerve supply. Dissection and lateral retraction of the serratus group exposed the medial part of the ribs and the intercostal muscles. The ribs were exposed subperiosteally and divided 1 to 2 centimetres lateral to the tip of the transverse process. The subperiosteal dissection proceeded medially to the transverse process. The costotransverse ligaments were then divided and by blunt dissection in the paravertebral gutter, aided by rotatory manipulation of the divided rib, the proximal part of the rib, its neck and head could usually be removed in one piece. Occasionally the head of the rib was removed piecemeal in order to avoid danger of damage to the pleura. No significant blood loss occurred in the operation, although the intercostal vessels were occasionally damaged. Any haemorrhage was easily controlled by diathermy or intercostal muscle suture.

In the thirteen experimental animals a total of fifty-nine rib heads were excised. In five of these manipulations the pleura was inadvertently opened. Forced ventilation with the face mask allowed confirmation of a continuing lung air leak. Simple suture of the pleural defect and closure of the intercostal muscles over the hole was always sufficient to prevent further air leakage. In these cases an intravenous plastic cannula was inserted through an upper intercostal space and connected through an underwater drain to a low-pressure pump. Complete expansion of the lung was usually obtained within a short time. In no case was it necessary to continue pleural drainage for more than one hour.

In each experiment, four or five of the lower rib heads were excised. After completion of the rib excision the muscle layers were sutured, after insufflation with antibiotic powder, and the skin closed with a continuous suture. A plastic film dressing was applied. Crystalline penicillin, 5 million units daily, was administered for five days.

Ten to fourteen days after operation the animals were again sedated with phencyclidine, the skin suture removed and the spine radiographed. Thereafter at two to three monthly intervals further radiographs were taken under “Sernylan” sedation. Radiographs were taken with the animal held under traction to all four limbs, in order to limit the possibility of postural deformity appearing as a true scoliosis.

**RESULTS**

There were no post-operative complications. Three animals died during the first year after operation, at five, seven and eight months respectively. In no case were
signs of pulmonary dysfunction or of surgical sepsis found. Death in all three animals resulted from gastrointestinal infection.

Figure 3—Radiograph of a baboon two weeks after excision of the heads and necks of the seventh to eleventh ribs. Figure 4—Radiograph of a baboon five months after excision of the heads of the eighth to the eleventh left ribs. There is no spinal deformity.

Figure 5—The animal shown in Figure 4. Nine months after operation there is a very mild deformity opposite the area of resection of the lower five rib heads. There is no compensatory curve above or below. The slight rotation continues well below the segments in which operation was performed. The asymmetry of the rib cage suggests that the positioning of the animal for x-ray examination was faulty. At necropsy (specimen shown in Figure 1) no scoliosis was present. Figure 6—The same monkey. One year after operation no deformity of significance is present. There is some reconstitution of the proximal ends of the ribs.

In no case was a progressive spinal deformity produced. Although in several animals an apparent deformity was seen on one or more of the post-operative radiographs, this was never more than a very minor curve and in no case did progression occur. All the animals grew during the post-operative period. Weight increases ranged from 2 to 9 kilograms. Once the immediate post-operative period had passed, the animals showed no signs of functional disability. One year after operation, the experiments were discontinued (Figs. 3 to 6).

**DISCUSSION**

The failure of these experiments was a disappointment, since it had been hoped to use the experimental model for further work on the fixation of Harrington instruments on a spinal column which anatomically so closely resembles that of man (Robin, Stein, Simkin and Siegel 1974). The reasons for failure are not clear. Langenkiöld's suggestion that interference with the costo-transverse ligaments is a factor in inducing scoliosis has not been confirmed in the erect animal, even if it is true in the four-legged animals used previously. Piggott (1968) felt that the absence of the proximal rib altered the mechanics of pressure on the growing vertebrae, with ensuing effects on the growth plates of the spine. This has not been shown in the spine of the growing baboon.

Few attempts to produce scoliosis in primates have been reported. Silva (1970) tried to induce a scoliosis in rhesus monkeys by excision of intercostal nerves, by division of costo-transverse ligaments and by excision of the erector spinae muscle. The deformity produced was at most very slight, and since the radiographs illustrating his report were taken with the animal at rest, with no traction, even these slight deformities might be the result of faulty positioning. There was certainly no evidence of structural change in the vertebrae.

Stilwell (1962) attempted to produce spinal deformity in rhesus monkeys aged one to one and a half years. His technique included resection of the sacrospinalis muscle from one or both sides, and also division of the interspinous and interlaminar ligaments. Additional monkeys underwent various muscle resections and denervations with no success. In those animals in which the paravertebral muscles and the interspinal ligaments were destroyed, spinal deformity did occur, both kyphotic and scoliotic. However, in this long and well-documented article there is not a single illustration of a scoliosis that has been produced whereas many pictures of kyphosis are presented. Stilwell stated that the scoliosis was usually the result of changes in the intervertebral discs and not due to structural changes in the vertebral bodies. It must be assumed therefore that Stilwell's techniques were not really successful in producing scoliosis.

The results of these three attempts to produce scoliosis in primate animals by techniques that have been shown to be fairly effective in quadrupeds suggest that the differing mechanical factors operating play a different part in different animals, and especially that the difference of posture changes the importance of various factors. The
relative importance of gravity acting along the long axis of the spine and the pressures that this brings on the vertebral growth plates must far outweigh any minor change that the absence of rib head pressure can produce in the erect animal, whereas in the quadruped, rib head pressure acts very closely to the line of gravity and therefore its presence or absence may be of greater significance.

Two conclusions should be drawn from this experimental failure. Firstly, further attempts are essential to produce an experimental model of scoliosis in primate animals. Bobechko (1973) has produced lateral spinal deformity in pigs by implanted muscle stimulators. This technique should be tried in the erect animal, as should Liszka’s posterior root section (1961). The importance of developing an experimental model in the erect animal has been even more emphasised by the fact that some surgeons have already tried to translate their laboratory results in the quadruped to clinical use. The results of the experiments reported here suggest that the use of Langenskiöld’s experimental technique should not be expanded in clinical practice, at least until convincing proof of its value in humans is produced by the pioneers in this surgical technique.

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REFERENCES