(two cases only, and in the second the androgen was obtained by a technique that differed from the standard procedure); primary virilism, 1.6 to 2.5, mean 2.1; secondary virilism, 2.5 to 7.4, mean 4.2. The literature on this subject shows figures which cover the range 0.4 to 7.0, which is slightly wider than, but very similar to, the total range given above. In primary virilism it would appear that there is proportionally rather less biologically active material in the total ketosteroid than is encountered in the other two groups. Considering both sets of values—those for androgens and ketosteroid—in relation to their respective normal ranges, we find only one case (Case 1, Table V) in which the ketosteroid was well within normal limits while the corresponding androgens were definitely above normal. Here the ketosteroid determination failed to reveal the degree of abnormality present in the urine. Except for this, a somewhat unusual case clinically, the results of the investigation uphold the view that the ketosteroid determination alone can be relied upon to give adequate expression of the degree of abnormality in respect of cortical hyperfunction in adrenal cases of the type forming the subject of this study.

Summary

Ketosteroid output has been estimated in the following groups of cases: adrenal tumour, primary virilism, and secondary virilism.

Both primary virilism and adrenal tumour groups show very high excretion rates. At a pre-pubertal age it is impossible, solely on the basis of the ketosteroid output, to differentiate between adrenal hyperplasia and adrenal tumour.

Rather more than 50% of cases of secondary virilism give ketosteroid values that are within the normal female range. Some of these have ketosteroid/creatinine ratios that are higher than normal, for which reason this ratio is believed to have a diagnostic significance.

Three cases diagnosed as "feminism" (representing in males a near clinical counterpart of adrenal virilism in females) have shown a low ketosteroid excretion rate.

Comparative androgen and ketosteroid determinations in all groups support the view that the latter assay furnishes a reliable index of the cortical hyperfunction associated with virilism.

We are particularly indebted to Mr. L. R. Broster of Charing Cross Hospital, whose cases have constituted our main clinical material, and our warmest thanks are due to him for his close co-operation throughout. We also express our gratitude to Dr. E. C. Warner, Mr. Ian Fraser, Dr. H. W. Barber, and Dr. T. N. MacGregor for presenting us with interesting cases; to Dr. H. W. C. Vines for kindly communicating to us the results of his histological investigations; and to Dr. J. Adler for valuable assistance in compiling clinical notes.

The expenses of the investigation were defrayed by the late Lord Wakefield, whose generosity we acknowledge with a deep sense of gratitude.

REFERENCES

- Allen, C., and others (1939). *British Medical Journal*, **1**, 1220.
 Broster, L. R. (1940). *Ibid.*, **1**, 425.
 — (1941). *Ibid.*, **1**, 117.
 — and Vines, H. W. C. (1933). *The Adrenal Cortex*, Lewis, London.
 — Allen, C., Vines, H. W. C., Patterson, J., Greenwood, A. W., Marrian, G. F., and Butler, G. C. (1938). *The Adrenal Cortex and Intersexuality*, Chapman and Hall, London.
 Callow, R. K. (1938). *Proc. roy. Soc. Med.*, **31**, 841.
 Callow, N. H., Callow, R. K., and Emmens, C. W. (1938). *Biochem. J.*, **32**, 1312.
 — — — and Stroud, S. W. (1939). *Ibid.*, **1**, 76.
 — — — (1940). *J. Endocrinol.*, **2**, 88.
 Chou, C. Y., and Wang, C. W. (1939). *Chin. J. Physiol.*, **14**, 151.
 Crooke, A. C., and Callow, R. K. (1939). *Quart. J. Med.*, n.s., **8**, 233.
 Fraser, I. (1940). *Brit. J. Surg.*, **27**, 521.
 Friedgood, H. B., and Whidden, H. L. (1939). *New Engl. J. Med.*, **220**, 736.
 Nathanson, I. T., Towne, L. T., and Aub, J. C. (1939). *Endocrinology*, **24**, 335.

FLUOROSCOPIC CONTROL IN THE REDUCTION OF FRACTURES

BY

F. H. KEMP, M.B., Ch.B., M.R.C.P., D.M.R.

Assistant Radiologist, Radcliffe Infirmary, Oxford

Although fluoroscopic control in the reduction of fractures has been practised for many years the principles of protection from the risks of radiation promulgated at the second International Congress of Radiology in 1928 have not been generally accepted by the surgeons. Radiologists have always viewed the practice with misgiving and have discouraged it. In recent years, however, new impetus has been given to this type of work by the development of small, efficient, and cheap portable x-ray sets free from danger of electrical shock. These machines are often controlled and operated by surgeons without technical assistance and seldom under the direct supervision of a radiologist.

Some surgeons now maintain that the use of x rays for this purpose is of such assistance that it is essential in certain types of fracture, and actually manipulate fractures into position under the x-ray screen. Others use x-ray observation to see the result of their manipulation, while others are content with films.

It is for the radiologist to show how x rays may be applied to the greatest advantage without harm. His first duty is to point out the dangers involved from misuse; for x rays are essentially dangerous, and no warnings or precautions can render the use of them fool-proof. The surgeon who, in spite of all warnings, actually manipulates under x rays, exposing his hands to the direct beam, will suffer sooner or later from the cumulative effect of such exposures, even though no one of them has been sufficient to produce any noticeable change in the skin.

Recent experience in this country has prompted the Ministry of Health to issue a timely warning against the dangers of setting fractures and removing foreign bodies under the x-ray screen (E.M.S. Circular, 1941, Supp. 6, Sect. III).

That the dangers involved are real is well shown in an article by Leddy and Rigos (1941) from the Mayo Clinic, quoted by Jupe (1941), on 135 cases of severe radiodermatitis among physicians. In the period 1919-34 there were 55 cases, and from 1934 to 1939 a further 80 cases. All these had injuries to the skin manifesting as severe telangiectasis, keratosis, acute or chronic ulceration, or epithelioma (39 produced cancers in themselves). Cases with early changes such as erythema, fissured nails, rough skin, slight telangiectasis or mild pigmentary changes, atrophy of the fat pads, and hangnail were excluded. Out of the 135 cases 91 sustained injury during the fluoroscopy they had employed in the reduction of fractures or the localization of foreign bodies, 6 others from taking films, and 13 admitted that they "did a little x-ray work." The authors found that in general the injuries were due either to a lack of proper equipment or to deficient knowledge; possibly, in some cases, they were the result of inexperience or carelessness. The use of the x-ray screen in the reduction of fractures was strongly condemned unless the operator carefully measured the dose he received or was under the direct supervision of an experienced radiologist, or unless he used the recommended protective devices.

All this harm is unnecessary, for with knowledge and intelligent appreciation of the dangers involved the risks may be reduced to such proportions as to be negligible and quite justifiable if fluoroscopic control leads to better surgical results.

In response to a request from the surgical staff of the Accident Service in the Radcliffe Infirmary for advice on

the protection from the risks of radiation during fluoroscopy, we have attempted to draw up certain provisional regulations acceptable to surgeon and radiologist which will ensure that dangers are minimized if not entirely eliminated

A Satisfactory Scheme

The following is an account of what, in our opinion, constitutes a satisfactory scheme:

X-ray Equipment.—Any modern ward trolley unit which is completely shock-proof is suitable for fracture service. A smaller machine or transportable unit is apt to break down if used for screening. In the design of the ward trolley unit certain features are desirable if not essential. It should be easily mobile. The tube with its protective shield should be as small as possible and mounted so that it is adaptable for use in any position, with automatic locking devices for positions in the vertical and horizontal planes. The arm carrying the tube should rotate on the vertical supporting column so that the tube can be swung into position when required or removed for the surgeons' convenience. A standard fixed screening couch is unsuitable for our purpose because the surgeons wish to employ their own tables and appliances in the operating theatre or the plaster room. Although we admit that a screening couch incorporating mechanically coupled tube and screen with fixed shields for protection is safe provided it is used properly, we contend that this unit is essentially suited to the requirements of the radiologist rather than of the surgeon. Many couches are so constructed that they actually hinder the surgeon's movements and are not adaptable for screening in any position.

Operation of the Unit.—A trained technical assistant is directed to operate the machine under conditions of 3 mA, 50 to 60 kV, and 1 mm. of aluminium filtration at never less than 20 inches focus-screen distance.

Fluoroscopy.—In most instances we employ the Miller indirect fluoroscope incorporating a 7 in. by 5 in. fluorescent screen. The screen is activated by a beam directed downwards from an overhead tube, the beam being controlled to cover a circle not greater than 5 inches in diameter at 30 inches distance, a convenient-sized field. With tube and screen set up in this manner it is possible to view most fractures of the elbow, forearm, wrist, or hand in two planes by turning the limb. In cases in which the limb cannot be turned it is suitable for only one view, and a second must be made from the side. For this purpose the tube is directed so that the x-ray beam passes through the limb towards the surgeon, the spread of the beam being limited to a circle of 5 inches in diameter at 30 inches focus-screen distance. The screen is mounted behind lead glass of 1 mm. lead equivalent and fitted with handles covered by attached metal shields to protect the hands. Observations are made with a 15 in. by 12 in. fluorescent screen held in place by an assistant so that the circle of illumination appears in the centre of the screen. A similar procedure is adopted, using an under-couch tube, when it is impossible to screen from above at a satisfactory focus-screen distance.

We believe that the field of illumination should be the same for every case, for if different cones or a variable diaphragm are used to give fields of different sizes it is impossible for the operator to be familiar with the limits of safety imposed by any one of them. The conditions are not comparable to those of the radiologist screening a barium meal, in which it is customary to confine the beam to the part being examined, so that none of the direct rays pass to the screen without traversing the patient's tissues. Admittedly there are definite advantages to be claimed for this technique, using a variable diaphragm, but the radiologist is well protected, whereas the surgeon desires to dispense with any shield or apron which might in any way obstruct his movements. In these circumstances the surgeon must work with the x-ray machine under constant conditions of operation.

If a suitable cone is not available a diaphragm may be cut from a sheet of lead. It can be mounted on plywood and fixed to the tube or incorporated in a larger cone by means of strapping. We prefer a circular cone or diaphragm because, when the current is on, the surgeon is at once aware that the tube is properly centred.

Protection

The quantity of radiation which can be tolerated over a long period without ill effects is 0.2 *r* daily, which is known as the daily tolerance dose. Although this dose may be exceeded without apparent harm, it is unwise, for the cumulative effects of many repeated doses are apt to be more dangerous than one single over-exposure. If tissue changes do occur they will probably persist and prove intractable to treatment.

Under conditions of 3 mA, 60 kV, and 1 mm. of aluminium filtration, with the beam controlled by a cone to give a circular field 5 inches in diameter at 30 inches focus-screen distance, we measured 0.2 *r* in the direct beam in 2.3 seconds at 20 inches or 5.04 seconds at 30 inches, according to measurements for 5 *r* with the dosimeter. There was very little scattered radiation, for dental films exposed for 5 minutes at 10, 20, and 30 inches from the centre of the beam at the level of the tube head and at the level of the fluorescent screen showed no perceptible blackening when compared with other films given measured exposures and developed under standard conditions. After 10 minutes there was a faint exposure on the film placed 10 inches away from the centre of the beam at the level of the fluorescent screen, corresponding to a blackening value slightly less than 0.2 *r*.

In view of the figures obtained from these experiments we believe that the surgeon must in no circumstances expose his hands or any part of himself to the direct beam, which means that it is impossible to operate with safety under the screen. The surgeon must first manipulate without screen guidance and then view the result. On the other hand, protection from scattered radiation seems adequate provided that the total time of screening is limited, which is a great advantage, for a lead apron imposes restrictions on movement and cannot be worn during an open operation, so that very few surgeons will ever wear one. However, it is unwise to dispense with such protection without periodic tests under actual conditions of operation, for, unless the tube head is properly screened and the proper-sized cone or diaphragm is in place, leaving no clear space between the tube outlet and the cone, there may be some risk. If a dental film is worn on the surgeon's gown during operation it should show no appreciable blackening when developed and compared with standard exposures.

We have repeatedly made satisfactory tests, using the Miller fluoroscopic box and with the tube set up for viewing from the side with a 15 in. by 12 in. fluorescent screen. There has been no occasion to use the under-couch tube for clinical practice, but trial tests seemed satisfactory.

Factors in the Practice of Fluoroscopy

It is quite clear that the practice of fluoroscopy must be limited, for under the conditions described the daily tolerance dose from scattered radiation may be reached in approximately 10 minutes if the surgeon stands close enough to the beam. Accordingly, the decision to employ fluoroscopic control in the reduction of a fracture is made only by an experienced surgeon who is responsible for the instruction of junior officers under direct supervision. On each case he spends as little time as possible. He manipulates with the current off and then views the result in a dim light.

Proper lighting is one of the most important factors influencing the total time of screening, for to make a quick decision the surgeon must be able to see as clearly as possible. We find that daylight screening is impracticable. Whenever circumstances permit, the operation is conducted in dimmed artificial light, with the lights so arranged that none of them shines direct into the surgeon's eyes or into the mirror of the indirect fluoroscope. It

should be possible to put out all the lights by a master switch hanging from the ceiling, which may be operated by the radiographer as he stands at the x-ray machine. If the surgeon cannot see clearly he must wait until his accommodation improves, and on no account ask the technical assistant to make the screen brighter. He must realize that even under the best conditions there are very definite limitations to the use of the screen. It is possible to view most of the bones of the extremities in antero-posterior and lateral projections, but in some instances, with fractures in the vicinity of the shoulder-joint or hip-joint in heavy subjects, fluoroscopy is useless.

Under suitable conditions we have determined that a single exposure of 12 seconds, the usual limit of the time clock, is sufficient to show alignment. The total time of screening for each case has been fixed at one minute, thus allowing five attempts to be made to achieve reduction. In the event of a house-surgeon failing to complete reduction the case is referred to the surgeon in charge. No one is allowed to screen for more than 5 minutes daily.

The radiographer in attendance at the operation is instructed never to permit free use of the tube, but to set the time clock for relays of 12 seconds' exposure, allowing an interval of 2 minutes between each, and never exceeding a total screening time of one minute without warning the surgeon. The total screening time for each case is recorded in a book, which the surgeon is asked to sign. Subsequently the entries are checked by the radiologist.

Before applying plaster to the limb the position of the fragments is checked by clinical inspection of the whole limb in a good light, and the findings are verified by radiography. Satisfactory films should show true antero-posterior and lateral projections of the joint above the fracture, the fracture site, and the joint below. Only in this way is it possible to judge the alignment of the distal joint surfaces on those above. In some instances in which there is pre-existing deformity it may be necessary to make a comparison with the opposite side. These precautions are essential, for it is very easy to miss considerable deformities by radiographic methods alone, especially when the limb is encased in plaster.

During radiography the surgeon must on no account hold a cassette in place or stand in the path of the x-ray beam, for a single exposure exceeds the tolerance dose of 0.2 r. As a measure of general health, all members of the surgical staff engaged in the accident service are advised to have blood counts at three-monthly intervals.

These views have been summarized in the form of provisional regulations on the screening of fractures. A printed copy is hanging in the surgeon's room, where it may be seen by new-comers. Another copy has been issued to all radiographers.

Our experience to date shows that the scheme is working very well, although there remain details to be worked out. The records in the radiographers' book may ultimately yield useful information as well as provide a check on the amount of work done. Already they have shown that in 3 out of 5 cases in the hands of the senior surgeon the total screening time was under 6 seconds in each case, reduction being subsequently verified by films, whereas the junior surgeons screen for much longer periods. No one has screened for more than one minute.

Conclusions

In proper hands the viewing of fractures with the x-ray screen to observe alignment after manipulation is a safe procedure, providing that it is carried out under well-defined conditions over which there is adequate control.

On no account must fractures be actually manipulated under the screen.

An account is given of the provisional regulations which have been accepted by the surgical staff of the Radcliffe Infirmary. It is hoped that others will be tempted to put forward their views and that ultimately general recommendations will be framed to help the surgeon. Later it may be possible to develop apparatus which will enable the work to be carried out under ideal conditions for the protection of the operator.

I wish to acknowledge the help of Mr. J. C. Scott, surgeon in charge of the accident service, and his assistants; and to thank Messrs. Philips Metalix for full details about the Miller fluoroscope. Eastman dental films were used to make the physical measurements. I am indebted to Dr. J. F. Brailsford for his encouragement to proceed with this paper, to Dr. G. Spiegler for his criticism of the physical experiments, and to Dr. A. E. Barclay and Dr. H. Courtney Gage for personal communications about their own experiences.

BIBLIOGRAPHY

- Barclay, A. E., and Cox, S. (1933). In Barclay's *The Digestive Tract*, p. 343, University Press, Cambridge.
British Medical Journal (1941), **2**, 165.
 Jupe, M. H. (1941). *Ibid.*, **2**, 175.
 Leddy, E. T., and Rigos, F. J. (1941). *Amer. J. Roentgen.*, **45**, 696.
 Miller, H. (1941). *Brit. J. Radiol.*, **14**, 77.

A SIMPLE METHOD OF REDUCING MID-SHAFT FRACTURES OF THE HUMERUS

BY

G. D. ROWLEY, M.B., Ch.B.

Major, R.A.M.C.

Generally speaking, fractures of the middle third of the humerus present little difficulty in securing accurate reduction. There are, however, cases which defeat the efforts of the most experienced manipulator. Considering the close relation of the musculo-spiral nerve to this part of the humerus, it is conceivable that over-energetic attempts at reduction could account for some of the cases showing damage to this nerve. There is a tendency to accept a reduction with varying degrees of displacement providing alignment is good. This is often seen in the simple transverse fracture showing backward and upward displacement of the lower fragment. A simple method of reducing fractures of the shaft of the humerus is here described whereby the likelihood of these complications arising is minimized. Two illustrative cases are recorded.

Details of Method

The patient is seated on an adjustable stool (theatre type), facing the head end of the operating table, with hand in pronation resting on the edge (Fig. 1). An ordinary adjustable stand, the type generally used for holding a gravity reservoir, is placed behind and on the injured side, with the hook of the movable rod over the point of the shoulder. Strong 2-inch webbing fitted with a buckle is passed under the axilla and hung on the hook of the stand. Protective felt is placed in the axilla to prevent pressure. The movable rod is now adjusted until the shoulder girdle is well supported. By moving the operating table backwards or forwards the arm is brought to the perpendicular, and by moving the table up or down the forearm is brought at right angles to the upper arm. Strong cord, threaded through protective felt, is placed round the forearm close to the elbow-joint, and 15 to 20 lb. is fixed to it. The position of the limb is then rechecked, and the weight is allowed to exert traction for from twenty to thirty minutes. No anaesthetic is necessary, as the patient stands the