RECENT ADVANCES IN X-RAY TELEVISION

WITH SPECIAL REFERENCE TO UROLOGY

BY

HOWARD G. HANLEY, M.D., F.R.C.S.

F. G. GREENWOOD, M.R.C.S., L.R.C.P.
D.T.M.&H., D.M.R.E.

AND

M. GILBERT SCOTT, M.R.C.S., L.R.C.P.
D.M.R.D.

Hillingdon Hospital, Middlesex

Since the previous reports (Hanley, 1955, 1956; Greenwood, 1956, 1957) we have had five further years' experience with various forms of x-ray intensification, and it is becoming possible to assess the routine clinical value as opposed to the academic interest value of the various procedures and possibilities when applied to urology.

The relative advantages of the various types of apparatus depend upon the clinical information we require. For the urologist, the ability to watch the movements of the pelvis and ureter has opened up a new vista of clinical investigation, and one cannot now contemplate retrograde pyelography without visual control. However, not all of the types of apparatus available are of equal value to the urologist whatever the radiologists may think, and certain basic requirements are necessary.

Firstly, viewing of the screen or monitor must be binocular and two or more persons must be able to view simultaneously. It is not sufficient for the urologist to be told what the radiologist sees—he must be able to see for himself. Secondly, this viewing must be possible without acrobatics. The original monocular eyepiece was unsatisfactory in both respects. The size of the field is also important, because, although in principle the smaller the field the better the definition, it is very useful to have a large field for rapid localization before coning down on specialized areas. The field of the Marconi orthicon system can include both kidneys simultaneously if required.

The next essential is that it must be possible to take "spot films" of the area localized on the screen with the minimum of delay or alteration of the apparatus. Lastly, the apparatus must be easily accessible for the urologist and an anaesthetized patient.

Whereas five years ago only two makes of intensifier tubes were available, to-day there are several varieties to choose from, while even the original basic principles of x-ray intensification have not remained unchallenged, and there are now two completely different systems.

Principles of Image Intensification

In non-technical language, a bright visual image can easily be produced on any standard fluorescent screen by the use of a high x-ray output. Unfortunately such x-ray dosage can be utilized for very short periods only, and this has always been the limiting factor in fluoroscopy. X-ray intensification is well on the way to solving this problem, by using electronic devices to amplify weak signals which in themselves would not be strong enough to produce a visual image on a

fluorescent screen. In other words, more visual light is obtained with a smaller x-ray dosage.

Although the electronic equipment is extremely complex and ingenious, the basic principles of intensification are simple. In place of a normal fluorescent screen which converts x rays into visual light, the intensifier tube converts the x-ray signals via light into electrons which are accelerated and focused down in the tube to produce an extremely bright visual image of reduced size on a small screen at the other end. This bright image can then be viewed through a suitable optical system or photographed with a cine camera. By replacing the cine camera or optical viewer with a suitable television camera, the resultant image can be seen on a monitoring screen, either alongside the x-ray table or away in another part of the building. This application of television has at last overcome the difficulties of viewing in ordinary room-lighting by an unlimited number of persons, and the value of this for teaching purposes cannot be overemphasized. It also means that the surgeon can see what he is doing and still remain surgically sterile, thus greatly simplifying the various operative procedures which x-ray intensification has made possible.

Recent Advances

The development of television for fluoroscopy has proceeded on two distinct lines. In the older systems an image-intensifier tube provides the light gain, and a vidicon camera is then used to scan the output phosphor and thereby produces a visual image on an orthodox television monitor. The most recent development in this field utilizes a completely different principle which dispenses with the intensifier tube.

The Orthicon Television Camera

The necessary light gain in this system is obtained by the use of a very sensitive orthicon television camera, which scans a modified conventional fluoroscopic screen, the final visual image being produced on a special high-definition 1,024-line television monitor. Provided a minimal light signal is received by the orthicon camera,

FIG. 1.—A, Image Intensifier System. An intensifier tube produces a very bright visual image on a small fluorescent phosphor. This image is recorded by a conventional vidicon television camera and subsequently reproduced on a television monitor. B, Marconi Orthicon System. The intensifier tube is omitted, but the light-gain is obtained by the use of a highly sensitive orthicon camera which photographs a modified conventional fluorescent x-ray screen. The subsequent picture is shown on a special 1,024-line monitor tube which gives much-improved definition.

the brightness and contrast of the monitor can be controlled entirely by manual adjustment in the same way as a domestic television receiver.

The basic differences between the two systems are shown in Fig. 1. It will be appreciated that the vidicon camera is essentially an industrial product, whereas the orthicon is a precision instrument of very high grade developed for the difficult conditions of outside broadcasting. For this particular work the orthicon camera has been modified from the standard television type by incorporating a wider target to mesh-spacing in order to achieve a greater sensitivity. The orthicon camera is more complex and therefore more expensive than the vidicon, and one obviously needs to find good reasons for using this and discarding the great light gain already obtainable with the image intensifier tube.

The main advantages of the orthicon camera system are: (1) the greatly increased definition and improved grey scale of the monitor picture due to the greater sensitivity of the orthicon itself, and the adoption of a 1,024-line system; and (2) the increase in size of the field from a circle of 64 sq. in. (413 sq. cm.) (the largest practicable with the intensifier) to a rectangular field of 110 sq. in. (710 sq. cm.). This increase is obviously of less importance in urology than in thoracic or cardiac work.

The apparatus has great versatility. The image can be doubled in size, shown on the monitor as a positive or negative shadow, and if required projected upside down. This inversion of the image is not of great importance in pyelography unless an extreme Trendelenburg position is required, but for femoral arteriography or cardiac catheterization it does allow an approach to either limb from the free side of the table, without having to view or photograph an

inverted picture. Finally, by using a camera lens of 25-mm. instead of 15-mm. focal length, the film image can be further magnified by two.

There are, of course, certain disadvantages of the orthicon, the chief of which is expense, though this may become less of a problem in the future. The set is certainly bulky, but this is to a large extent capable of being counteracted by good engineering (Fig. 2), and the great possibilities of further development would indicate that this is the logical line of progress for the future.

Cinematography

It was originally thought that the necessity of having to film the television monitor before one could obtain a cine record was a major difficulty. However, this has

FIG. 3.—Cine films are obtained by photographing a separate monitor tube with a 16-mm. camera, the shutter speeds of which are phased with the 50-cycle A.C. mains. 25 and 16½ frames per second are convenient speeds for standard sound and silent projection.

not proved to be the case (Fig. 3). Certainly the cine camera has to be phased to the 50-cycle input main in order to avoid stroboscopic effects, but two of the speeds available (25 and 16½ frames per second) are very conveniently close to the standard sound and silent projection speeds, while the ample amount of light and contrast make possible the use of fine-grain 16-mm. film. This can be processed easily in the x-ray department and projected within a few hours if necessary, the end results being in every way comparable with those obtained by photographing the phosphor. Certainly a 35-mm. camera is no longer necessary.

Clinical Applications

The value of x-ray fluoroscopy has already been demonstrated in many types of clinical investigation (Hanley, 1957, 1958, 1959a, 1959b, 1960; Stevenson, 1957, 1960), so that the versatility and increased efficiency of the orthicon system will doubtless lead to even further use and development.

Excretion Pyelography

The cumulative x-ray dose to the radiologist must prohibit the use of this method for routine excretion pyelograms, but, quite apart from this, our experience shows that the value of intensification is limited because full-size films of first-class quality of the whole tract are essential for preliminary assessment of every patient. This means that the standard I.V.P. examination is still required in the first instance. However, having made this preliminary assessment there are occasions when the use of fluoroscopy is invaluable for studying the dynamics of the tract, using medium excreted by the kidneys rather than medium injected in a retrograde manner. This is particularly so in children or thin adults where good contrast can be obtained using

FIG. 2.—The orthicon unit is suspended above a standard tilting table, and can be elevated out of the way when the table is used for conventional radiography. The monitor is also suspended from a ceiling rail and can be rotated, raised, or moved away altogether when not in use.

double-dosage injections. For example, micturating cystograms in children can often be performed without the passage of a catheter, which is obviously desirable when possible, while the normal emptying of the renal pelvis can be studied in the upright position without the presence of a foreign body. This permits differentiation between an atonic pelvis which may be physiologically normal and a truly obstructed or tonic pelvi-ureteric junction which may require surgery.

Nevertheless in spite of the undoubted value of the intensifier for excretion pyelography in certain special instances, its value in routine diagnostic work is limited by the relatively poor density of the contrast medium excreted by the kidney. The newer triiodine molecule compounds have certainly been a great advance on the older substances, but there is still much room for improvement.

Retrograde Pyelography

Retrograde pyelography has been completely revolutionized by the use of visual screening under an intensifier, and we now seldom perform this examination in the old-fashioned way without visual control. The advantages are many. Not only can the dynamics of filling and emptying be studied visually, but the value and quality of the spot films are improved, while the localization of special areas of the tract is made completely accurate.

The ureteric catheter can be passed in the operating theatre or on the x-ray table (for preference), and it is only a matter of seconds to visualize the tip of the catheter on the screen and to fill the pelvis under direct vision. The dangers of overfilling and the frustration of underfilling are eliminated and a small spot film is taken at the optimum moment. The whole operation is therefore an exact as opposed to a hit-or-miss procedure. When the spot film has been developed the catheter is withdrawn and, using moderate "foot-down" table tilt, the emptying of the pelvis is watched on the screen. This latter observation proves invaluable time and time again, and among other things has twice revealed the presence of non-opaque ureteric stones and once drew attention to a small ureteric carcinoma which had not been revealed in the excretion or the ordinary retrograde pyelogram. Quite apart from a saving of time and x-ray film, the area of body irradiation is much reduced by the coning down of the x rays when exposing the small spot film, and this is of great importance.

The quality of the films obtained by this technique is extremely good, while the additional information to be obtained from the visual screening is such as to make one wonder how it was ever possible to do without such facilities.

However, the greatest benefit results from the fact that the maximum information is obtained at the first attempt, for there is nothing less excusable than subjecting a patient to the undoubted risks of retrograde pyelography and then failing to obtain satisfactory radiographs.

Cystography

The technique of cystography has been revolutionized by the introduction of cine-fluoroscopy. Previously a micturating cystogram obtained by a series of still exposures might or might not demonstrate the important phases of filling and emptying of the urethra, or perhaps of ureteric reflux, but a cine film can record the whole cycle of micturition, and can be studied repeatedly and

at leisure. Our experiences so far indicate that our knowledge of the basic physiology of the ureter and bladder is only in its infancy.

Other Fields

Gastro-intestinal Examinations.—The equipment is very convenient for the examination of the pharynx and oesophagus where conditions are ideal, with high contrast between the air-filled lung and the barium. When the camera is used, high frame speeds allow projection in relatively slow motion so that the complete cycle of deglutition can be followed in detail down to the stomach. Very minute pharyngeal diverticula can be shown convincingly by this method. In the examination of the stomach, conditions are less favourable for cine-radiography, but it has value in demonstrating rigidity and absence of peristalsis in the stomach wall. Movements of the small bowel are very satisfactorily rendered on cinematograph film and there is throughout the great convenience of screening without prior dark accommodation.

Bronchography and Angiography.—The large field size—110 sq. in (710 sq. cm.)—is of great help when examining the heart and lungs. Selective bronchography can be carried out in excellent lighting conditions and, as in urology, discussion between the radiologist and the clinician during the examination is very helpful. In angiocardiology and cardiac catheterization the screening qualities are quite outstanding, and it is here that inversion of the screen image can be very helpful. The quality of cine-radiography cannot, of course, approach that obtained by full-sized films, and with a single injection of medium, biplane examination is not possible. It may well be that some combination of the two methods will eventually be evolved.

Myelography and Ventriculography.—Here, again, collaboration between surgeon and radiologist is facilitated. Accurate positioning for spot-film technique enhances the value of the examination and reduces the number of films necessary, while it is surprising to find that screening of the lumbosacral area, even in the lateral position, has proved most satisfactory.

Orthopaedics.—Here there is obviously an enormous field available which one has not yet had time to cover. Fracture-setting, joint movement, and arthrography using opaque media are all obvious applications. Provided sterile conditions can be achieved, it would seem that the method may be applied safely to the insertion of intramedullary nails and possibly Smith-Petersen pinning of the femur. The field here would appear so enormous that radiologists will obviously be concerned at the amount of screen examinations that may be called for, as, although dosage is extremely low, one cannot ignore cumulative effects.

Hysterosalpingography.—Fluoroscopy during this examination is now a routine procedure, while the use of magnification technique opens up a new field of research into the effect of relaxant drugs on the Fallopian tubes. In no other investigation is the reduction of radiation dosage of so much importance.

Summary

Our further experience with x-ray intensification indicates that some form of television monitoring will become standard practice. The scope of fluoroscopy

has already been greatly increased, while the anticipated difficulties of photographing the television monitor have been overcome.

The Marconi orthicon system, apart from its larger field, would appear to be the most efficient and versatile apparatus at present available, and seems to offer more scope for future development than does the combination of an intensifier tube and a vidicon camera.

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NATIONAL SURVEY OF PERINATAL MORTALITY

FIRST RESULTS

The first results of the National Perinatal Mortality Survey, carried out under the auspices of the National Birthday Trust Fund, were presented at a meeting of the Paediatric Section of the Royal Society of Medicine on April 28. The Survey covered England, Scotland, and Wales.

The director of the Survey, Dr. NEVILLE BUTLER, said that the Survey provided data on perinatal deaths which would have taken an obstetric hospital of average size 250 years to collect; in addition, administrative and clinical data on a control group of one week's national births had been obtained. A large questionnaire completed one week after delivery or death of the baby, which covered the antenatal period, labour, and details of the infant, was given a successful trial run in Nottingham and Bristol and then launched nationally in March, 1958. Completed questionnaires were received on 17,077 births occurring in the week March 3-9 and on 7,932 stillbirths and neonatal deaths taking place in March, April, and May, 1958. These returns represented 98% and 95% respectively of the notified occurrences in England, Scotland, and Wales. In addition, necropsies had been carried out at special centres on 88% of those stillbirths and neonatal deaths occurring in March, 1958. The results now presented were based on a 1 in 3 sample of one week's births and on the March stillbirths and neonatal deaths. Analysis of the full 25,000 cases would be reported later.

Antenatal Care

A review of the antenatal services had revealed interesting features. Twenty per cent. of primiparae and 66% of grand multiparae were booked for domiciliary delivery. But nearly a fifth of these women were admitted later to hospital as emergencies during pregnancy or labour. Cases were analysed according to whether they attended a hospital, local health authority clinic, general practitioner, or midwife. One in three of all women attended a single place of antenatal care, 50% attended two places, and 14% three or more. This multiplicity was of importance, especially as full antenatal notes were reported as not being available in 25% of all deliveries. One-half of mothers attended a hospital antenatal clinic at least once throughout their pregnancy, but this proportion was not greater in cases with a previous neonatal death or toxæmia of pregnancy. First attendance for antenatal care was before

the sixteenth week in only 48% of all women, though 70% had attended by the twentieth week. Grand multiparae, unmarried mothers, and women over 40 years all presented later than the average. Hospital bookings were made on the average earlier than domiciliary. Statistics on total attendances during pregnancy, irrespective of quality or spacing, showed that 88% of all women had attended at least six times, but only 1 in 3 women attended on 12 or more occasions.

As indirect measures of quality of the antenatal services, inquiry was made about rhesus group, haemoglobin test, and chest x-ray during pregnancy. The rhesus blood-group was not available in 5% of all deliveries and in 10% of those who received antenatal care completely outside hospital or local health authority clinics. The haemoglobin was not estimated in 32% of all cases and in 60% of those receiving antenatal care solely under the domiciliary service. Chest x-ray was performed in 30% of all patients. Finally, 1 in 6 of all mothers reported that their blood-pressure had not been taken on every antenatal visit. It was unlikely that there had been any major change in the standard of care since the date of the survey.

Respiratory Distress Syndromes

Dr. Butler then presented preliminary clinical associations for 100 deaths from hyaline membrane and 52 from massive pulmonary haemorrhage. Males preponderated in each (65%); the incidence of twins was high (22% and 14%). Complications at delivery were commoner preceding hyaline membrane: for example, placenta praevia in 11%, but in pulmonary haemorrhage nil; caesarean section in 27%, but in pulmonary haemorrhage 16%. Complications of pregnancy predominated in pulmonary haemorrhage cases, toxæmia in 65% (25% in hyaline membrane) and "small for dates"—a birth-weight of at least 1,000 grammes less than the average for gestation—in 55% (33% in hyaline membrane), both these differences being significant. Death occurred by 48 hours in 93% of cases of hyaline membrane. The onset of symptoms in pulmonary haemorrhage was usually after the second day, with a maximum mortality on the 3rd-5th day; convulsions occurred in 50% without any intracranial lesion except oedema; haemoptysis (40%) was unaccompanied by other haemorrhages, and vitamin K had been given prophylactically in 45%. Sedation had often been very heavy during labour, and placentae, where examined, were small.

Necropsy Findings

Dr. A. E. CLAIREAUX then gave the results of the March pathology inquiry. Special post-mortem examinations on stillborn foetuses and infants dying within 28 days from birth had been carried out during that month in England, Scotland, and Wales. In each regional hospital board area one or more laboratories agreed to undertake the majority of investigations in that part of the country. Foetal loss and neonatal death could unfortunately seldom be attributed to a single pathological or clinical cause. In order that the clinical and pathological factors could be correlated, the 2,368 perinatal deaths (i.e., stillbirths and first-week deaths) had been classified according to the major lesion found at necropsy. The Table shows the number, percentage incidence, and incidence per 1,000 total births for each lesion in March, 1958. About 10% had more than one major lesion, and these cases were attributed to the lesion considered least compatible with survival.

Signs of anoxia were the most prominent findings among the stillborn foetuses. They were present in 41% of the macerated foetuses, in 57.2% of fresh stillbirths, and in 11% of infants who died within one week. Forty-four per cent. of the macerated foetuses showed no lesion.

Severe congenital malformation accounted for 15.1% perinatal deaths. They were present in 14% of stillborn foetuses and in 18% of first-week deaths. One case in three had multiple lesions. The central nervous, alimentary, and cardiovascular systems were the most frequently affected. Resorption atelectasis, including cases with hyaline