AMBER: FOR CHEST, LARYNX AND ABDOMINAL RADIOGRAPHY

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ABSTRACT

Conventional radiography is limited by the small useful exposure range of radiographic film. The wide variation in absorption thickness of different parts of the body results in areas of under-and over exposure. An advanced multiple beam equalization system, **AMBER,** controls local exposure delivered to the film. The system has a row of 20 modulators in front of the x-ray tube, each able to change the height of the local slit beam during scanning. Changes are made in response to measurements from a linear detector array in front of the film cassette. This array consists of 20 individually functioning detectors coupled through electronic feedback loops to the 20 modulators. A scan is obtained in 0.8 second with a local exposure time of approximately 50 msec. **AMBER** results in radiographs with significantly improved exposure of the mediastinum without overexposure of the lungs. Originally, this system was aimed to use for the chest radiography, however, abdominal radiography and laryngeal radiography was used by us to illustrate the images produced by this machine.

Some tissues in the thoracic region are characterized by a relatively low absorption of x-rays (lung), whereas other tissues have a higher absorption (mediastinal, retrocardiac and subdiaphragmatic regions). This leads to great differences in the transmission of x-rays through the chest and to a necessary compromise between contrast and latitude of the film. In conventional radiography, these differences often exceed the dynamic range of the screen-film combination, even when commercially available wide-latitude films are used (1).

To overcome this problem, several solutions have been proposed. One of these solutions is a system based on a scanning multiple-beam equalization technique, advanced multiple-beam equalization radiography (AMBER)(2).

The **AMBER** unit was produced by Delft Instruments Medical Imaging, Delft, The Netherlands. It uses a horizontally oriented x-ray beam (slit technique) that scans the patient vertically. The fan shaped beam of radiation can be regarded as divided into 20 parallel segments, each covering approximately 1.3 square inches from a 1.6 X 0.8 square inch area. Each segment has its own modulator in front of the x-ray tube in a feedback loop with a corresponding detector. The detector array is located between the grid and the film cassette. When the image is obtained, the detector output signal is used to adjust the corresponding modulator to deliver the proper exposure to the part of the film covered by the detector. To reduce scatter, fore and aft slits and a grid are used. A standard x-ray tube is used, and a scanning time of 0.8 second can be achieved.

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The modulator, located with the fore slit in front of the x-ray tube, consists of 20 x-ray attenuation elements. Each element consists of an absorber on the tip of a piezoelectric actuator. Setting a voltage on the actuator causes the element to bend. Depending on the voltage, the absorber will more or less cover the fore slit collimator. When completely covering the fore slit, each absorber totally absorbs the local radiation. The voltage on the actuator is controlled with the measurements of the corresponding detector and feedback loop. During radiography, measurements of the detector will constantly cause the absorber to be set in different positions, thereby controlling the exposure to the section of film behind the detector. The height of the x-ray beam at the level of the detector is only slightly affected by different positions of the absorber. At a scanning time of 0.8 second, the local exposure time (50 msec) can therefore be calculated. Depending on the focus dimensions of the x-ray tube, the x-ray intensity distribution, the shape of the absorbers, and the size of the detectors, artifacts can appear on the image. Artifacts in the scanning direction can be caused by ineffective smoothing of the overlap area between two absorbers set at different positions.

The xenon detector is actually composed of 160 detector strips, in 20 segments of eight strips. Sampling of the detector is performed over an area of 1.6 X 0.6 inch to avoid cross talk between parallel detectors. Each detector measures the x-ray intensity after it has passed through the modulator as well as the patient. Since the detector chamber is in front of the film cassette, the material must be chosen so that no artifacts appear on the image.

This is achieved by using very thin electrodes that transmit more than 99.5% of the x-rays at 70 keV. This allows an extremely small contrast difference in respect to the wall material of the xenon detector. To keep patient x-ray exposure to a minimum, wall material with an absorption of less than 10% at 70 keV was chosen.

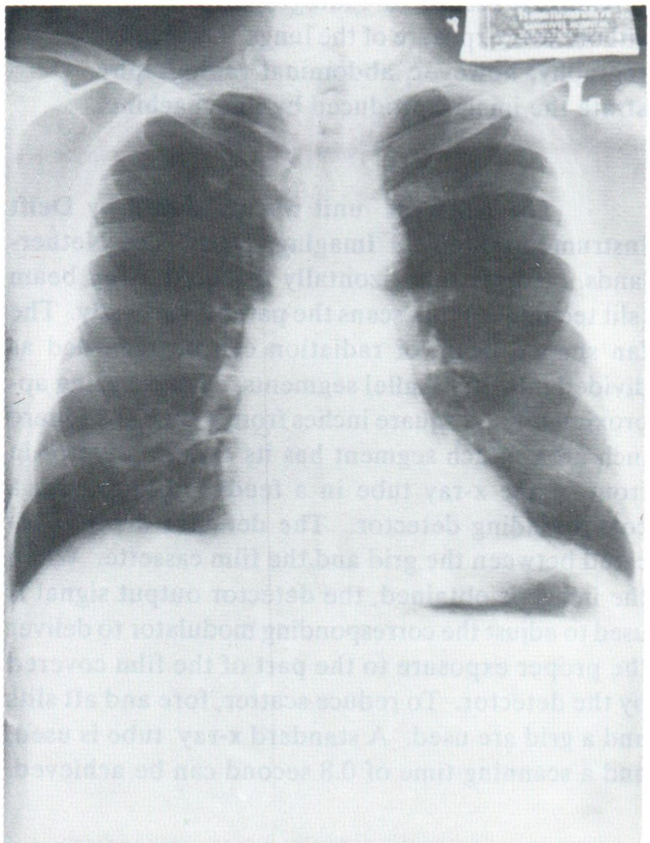

Fig. 1 a. Conventional chest film of the chest in P.A. view

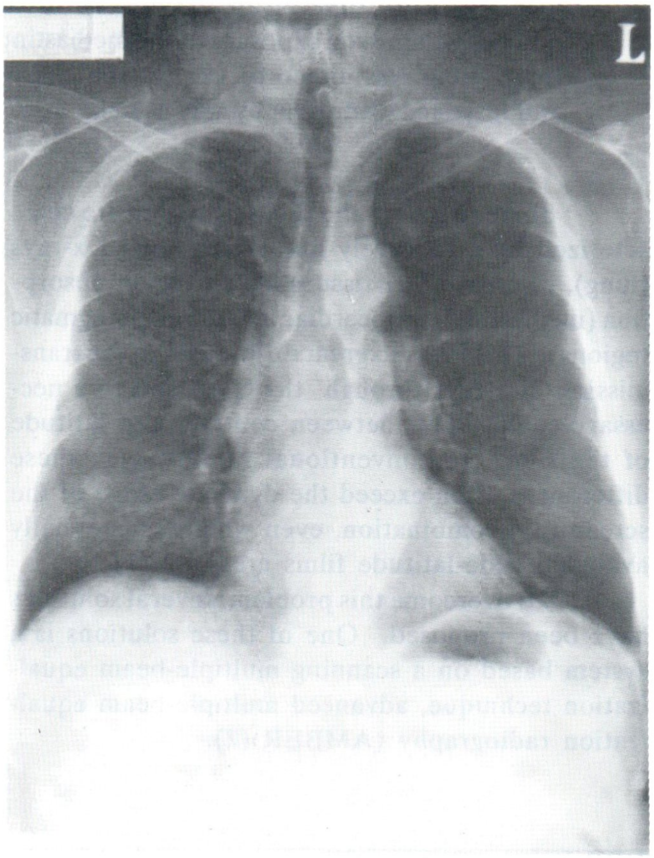

Fig. 1 b. Amber chest film of the same patient small nodule at RLL, clearly demonstrated even in rib-hidden

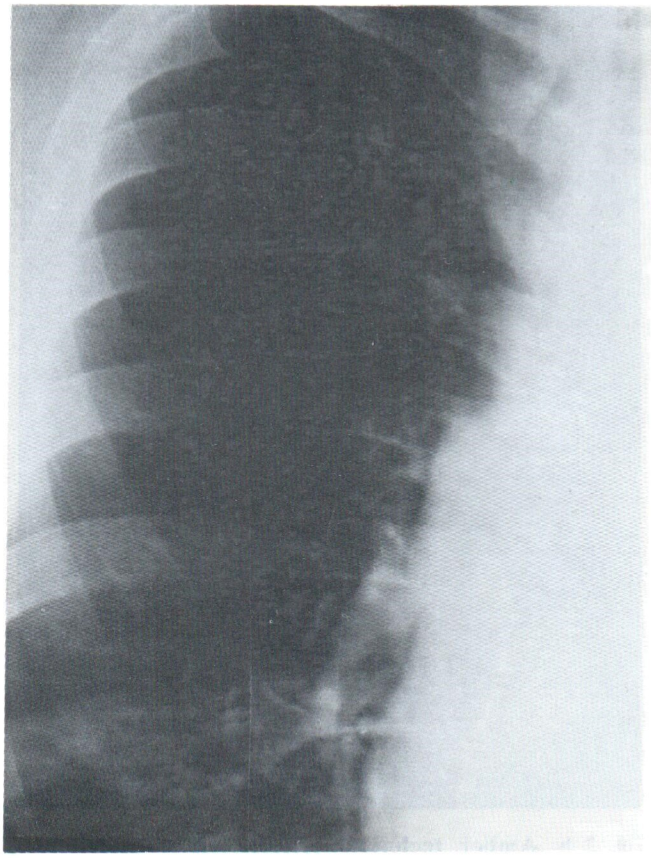

Fig 1 c. Conventional close up picture of right lower lobe

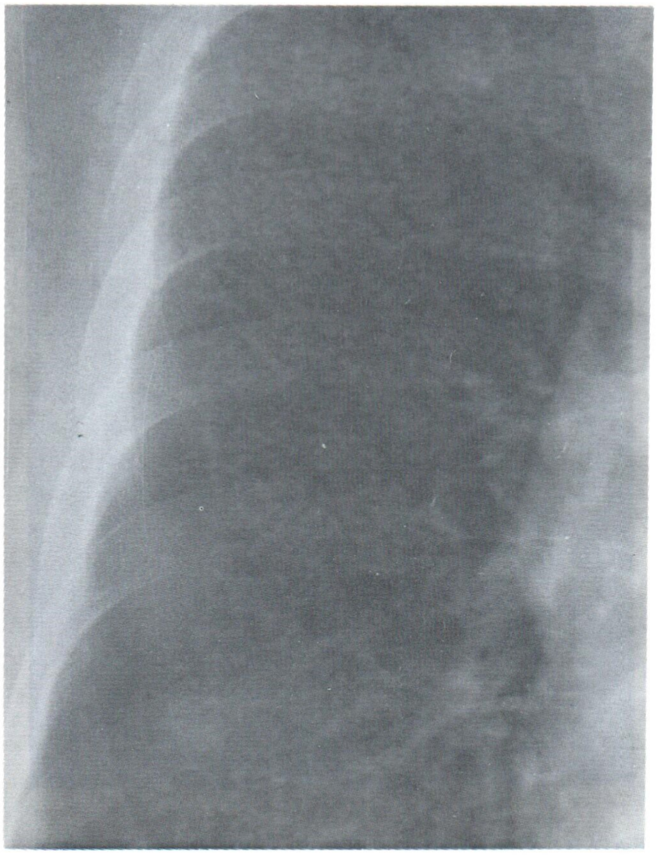

Fig 1d. Amber technique, close up picture of right lower lobe revealed the nodule more obviously

The detector signals are amplified electronically with 20 pre-and output amplifiers and one control amplifier. Only one control amplifier is needed because of the use of multiplex and demultiplex techniques. The microprocessor governing the control amplifier can be seen as the heart of the electronics. Different settings of both threshold value (above which the system starts to function) and control amplifier gain result in different control curves according to which the equalization takes place.(2)

Although **AMBER** has been described and used since 1988, the first machine was installed in Thailand in 1994 and is so far the only machine in the country. Images could be obtained only from the patient who could maintain the erect position. The main use is for chest radiography, however, the images of the upright abdomen and the larynx are also more informative than the conventional ones.

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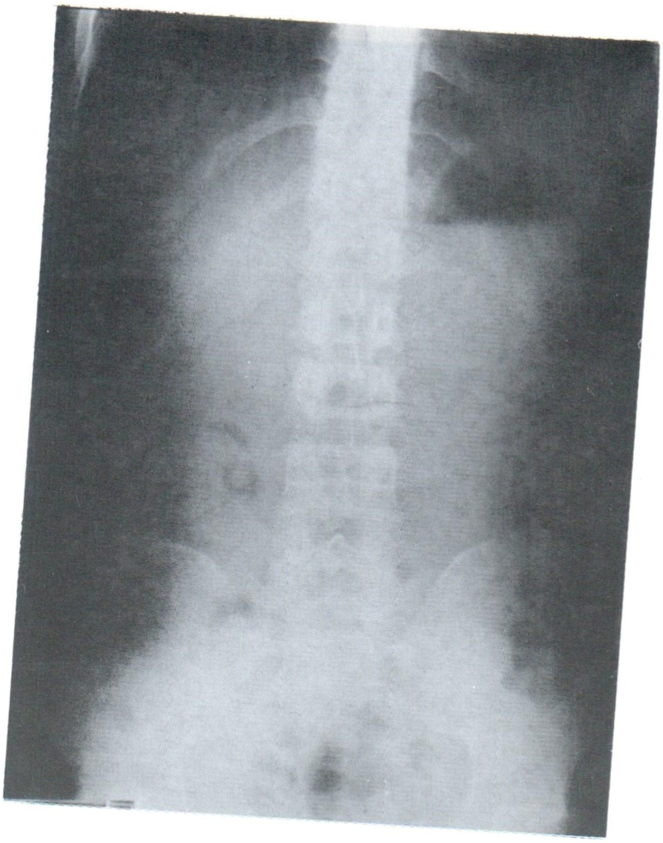

Fig. 2 a. Conventional technique of the upright abdomen.

Fig. 2 b. Amber technique of the upright abdomen. Better visualization of the spine and bowel loops. The lateral and central part of the abdomen is equally and beautifully seen.

Fig.3 a. Conventional technique of the neck in lateral view

Fig. 3 b. Amber technique of the neck in lateral view. Better visualization of the bony part, airway and soft part is shown.

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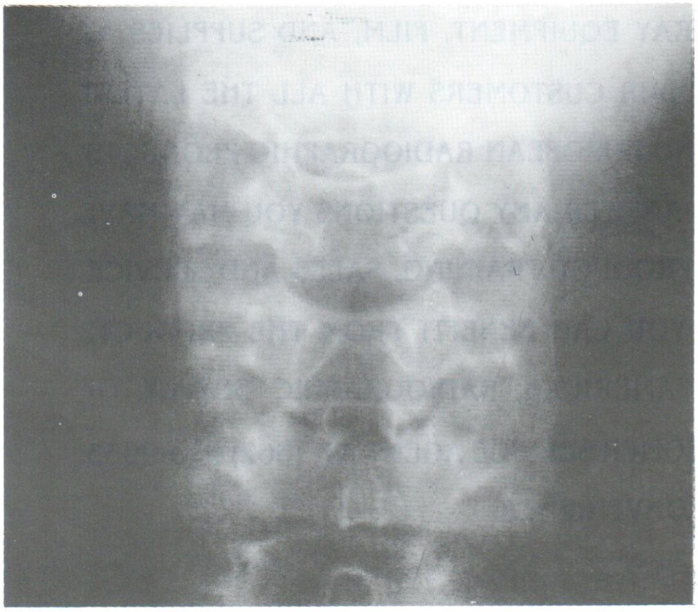

Fig. 3 c. Conventional technique of AP view of the neck.

Fig. 3 d. Amber technique of AP view of the neck. Nicely visualization of the pharyngeal, laryngeal and tracheal airway, the surrounding soft tissue and the bony parts.