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Osaka University
A SIMPLE AND REALISTIC CALCULATOR
FOR RADIOGRAPHY

By

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簡便にして忠実なる曝出計算尺

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(昭和38年6月6日受付)

レ線写真の複雑性のために，従来の曝出表又は計算尺は複雑にすぎ，又その上実験値の若干の修正を余儀なくされている。ここに報告する計算尺は最も少ない実験数で広汎な条件の組合せが可能で
あり，かつ実験値を何等修正する必要がない。従ってその製作は容易で簡単に行い得，また実験値の修正がないから計算尺にはレ線写真法の諸特性が忠実に描かれている。

Recerently it has come to be recognized that exposure factors should be determined not empirically but by using a table or a calculator. In most departments, a simple table representing the definite kilovoltage for each body thickness is used. Such a simple table can not allow a wide range application of radiation quality.

Many exposure tables and calculators for radiography have been reported by many authors, who have analyzed the influence of exposure factors on the radiographic effect precisely. A. Bierman (1951) and T. Shiga (1963) developed nomograms for the practical application of their experimental data. M. Simon (1956) and H. Okumura (1962) used rotating discs. G.S. Schwarz (1959) reported an X.V.S. unit system, similar to the E.V.S. system of photography, and devised a simple caliper scale and an automatic control.

On the basis of their calculators, many experiments were needed and also some modifications of the experimental data. They had to carry out many experiments and labored to find rules in order to simplify the relationships between exposure factors, for the complicated relationships made it impossible to plot them on a calculator without modification.

The calculator to be described here does not need so many experiments, labor to find rules or any modification of experimental data. One can plot the calculator with the experimental data themselves and easily read quite exact exposure factors. Even when the data of the calculator reported here can't be adapted to another machine, one can construct the calculator very easily from this idea.
Fig. 1. Optimal settings to produce unit density film, from experiments with a water-phantom.
Fig. 2 a  Plate A

Plates A, B and C are combined.
Method of Construction of our Calculator

The basic consideration of the calculator is to make a film of unit density over the shadow of the soft parts of the body.

1. How to experiment to obtain unit density with varying exposure factors.

As is shown in Fig. 1, experimental exposures were made at several points of thickness and kV to find proper mAs to produce unit density. One can diminish the number of experiments where the curve is linear or when a wide range of exposure is not needed.

2. How to plot the curves on the calculator.

As is shown in Fig. 2, a mAs scale is graduated logarithmically from 1 to 1000 mAs at the bottom of plate A. On a translucent plate B of the same length, a diagonal line of kV scale is graduated logarithmically over the full range of the machine. The calculator used is such that plate B is placed on the upper part of plate A and is slid parallel to the mAs scale, in the same way as a common slide rule. The calculator is completed when the curves of thickness are drawn according to the data from Fig. 1. At the beginning of this operation, a reference arrow between plate A and B must be marked at a definite point on plate B. For example, the optimal settings of 10 cm. thickness, 50 kV and 16 mAs are chosen. After plate B is placed accurately on plate A, the point of 50 kV on plate B is projected on plate A, and a dot of 10 cm. thickness is marked there. Then an arrow is marked at the bottom of plate B, corresponding to the point of 16 mAs on plate A.

In order to plot the optimal combination of "a" cm. thickness, "b" mAs and "c" kV, the point of "a" cm. can be plotted when the arrow is adjusted to "b" mAs and "c" kV is projected on plate A. Dots at 1 cm. intervals can be plotted on plate A from data interpolated from Fig. 1, and the curves of thickness are drawn by connecting dots of the same thickness.

3. Increase of mAs with the use of grid and correction factor.

The magnification of exposure with the use of Lysholm grids having ratios of 1:5 and 1:10 are shown at the upper and lower parts respectively, of the thickness curves. The phenomenon that magnification varies with both kV and thickness can be seen with a grid ratio of 1:10.

If the screen, film and development are different, the arrow must be moved. In Fig.2b, the correction factor of 1, 1.5 and 2x magnification intervals is marked. This factor can also be used to arrange mAs for different distances, but in our department plate C is added.

The Use of our Calculator.

When the thickness of the body is measured, one must be careful of the measuring point, considering which part is to be unit density. When the desirable kV is adjusted to the thickness measured, the arrow indicates mAs to produce a unit density film for 1 meter distance without a grid. If the mAs is not suitable, one can find a new kV, moving plate B, adjusting the arrow to the suitable mAs and reading the point of crossing of the kV line and the thickness curve.

When a grid is used, the correction factor scale helps to find the magnified mAs.

The use of this calculator is limited to areas of the body other than the chest and the
point of the arrow must be changed when a small field is under exposure.

**Characteristics of our Calculator.**

Our calculator has many good points:

1. It can be made very easily. It does not need many experiments or effort to find rules, and it can be applied to a wide range of exposures.

2. True settings can be obtained without any modification of the data from experiments.

3. One can use the calculator as easily as the common slide rule.

4. One can select the suitable quality of radiation to produce a film of desirable contrast.

5. One can realize the relationships between each exposure factor from the observation of the calculator.

6. One can plot the calculator even with the data obtained clinically, without any experiment, after the mechanism of the calculator is understood.

**Summary**

A simple and reliable calculator (slide rule type) is described, by which very satisfactory settings are easily obtained to produce a unit density film in a wide range of radiation quality.

**References**