SELECTION OF POLAROID FILM FOR SCINTIPHOTOGRAPHY

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The fundamental purpose of a radioisotope imaging system is to produce an image of such quality that the physician can recognize diagnostically significant detail. Virtually all systems use some form of photographic recording in the final production of the image, and this usually serves as the permanent record of the examination.

The picture images produced by the Anger scintillation camera and by some rectilinear scanners which use cathode-ray tubes (CRT) for data presentation are built up by integration on photographic film of discrete flashes of light emitted by the CRT. These scintiphotos are ordinarily produced on Polaroid film which yields a permanent record in 10–15 sec. The type of film selected for scintiphotography is of some interest because identical exposure conditions produce markedly different qualitative images when different film types are used.

Principally, there are four parameters that can be controlled in manufacturing photographic emulsions: image resolution, spectral sensitivity, film speed and contrast or tonal range. Image resolution is defined in terms of the number of parallel lines per millimeter which can be separated. This resolution is limited by the paper development process of all Polaroid films to approximately 22–28 lines/mm (somewhat lower for Polaroid Type 55 P/N) which far exceeds the resolution of any scanning device and therefore is of little consideration.

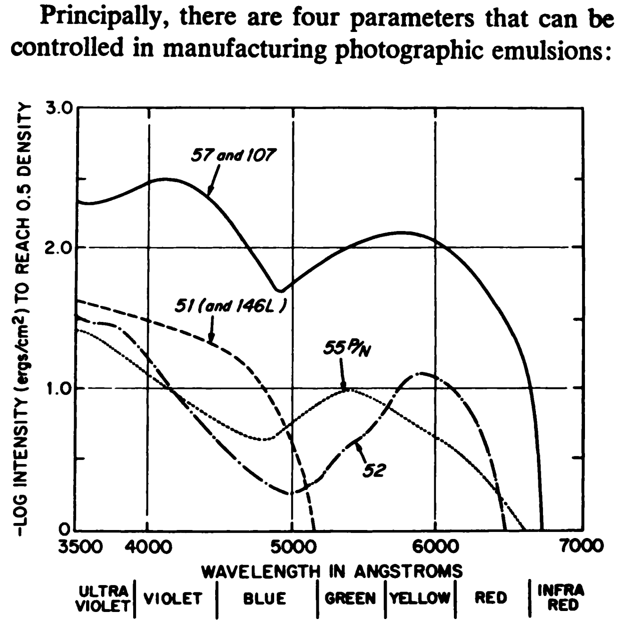

FIG. 1. Plot of negative log intensity to reach half-density exposure as function of light wavelength for four Polaroid films. Higher the curves for any given wavelength, greater is film's sensitivity for that light. (By permission of Polaroid Corp.)

Spectral sensitivity, which describes the film response to light wavelength, is again not a critical factor if the light from the CRT has a wavelength to which the film is sensitive. Figure 1 is a plot of negative log intensity to reach the half density exposure as a function of light wavelength for four Polaroid film types. The higher the curve for any given wavelength, the greater is the film's sensitivity. Note that Type 51 film is sensitive to blue light only but that the remainder are panchromatic.

Film speed depends on a variety of factors including emulsion properties, grain size, ambient temperature, development conditions, etc. Film speed is important because the duration of each flash of light on most CRTs is extremely short. A very slow film will require a more intense flash than a fast film. If increasing light intensity produces a larger dot size on the CRT, it is conceivable that image resolution will suffer.

Contrast, tonal range, gray scale and exposure latitude are all terms which depend on *film gamma,* defined as the maximum slope of the density as a function of the log radiant exposure curve of a film (see Fig. 2). Thus a film with a high gamma will record two different light intensities with a greater density difference than a lower gamma film. If a wide

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Received Feb. 28, 1968; revision accepted July 11, 1968.

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TABLE 1. POLAROID LAND FILMS

Format	Film type	Film speed	Gamma	Nature of film
4 × 5 Film Packets	51*	60 (tungsten) 200 (daylight)	3.0	Very high contrast. Sensitive to blue light only. 15-sec development time.
	52*	400 ASA	1.3–1.4	Medium contrast. Panchromatic 15-sec development time.
	55* P/N	50 ASA	1.4	Medium contrast. Black and white print and negative. 20-sec development.
	57*	3,200 ASA	1.1–1.2	Very high speed. Panchromatic. 15-sec development.
	58	75 ASA		Color print. 60-sec development.
3¼ × 4½ Roll Films	42	200 ASA	1.3–1.4	Same as Type 52.
	47	3,200 ASA	1.3–1.4	Similar to Type 57. 10-sec development.
	48	75 ASA		Same as Type 58.
	46-L	800 ASA	1.8	Medium contrast. Black and white transparencies. 2-min development.
	146-L	60 (tungsten) 200 (daylight)	2.5	High-contrast transparencies. 10-sec development.
	410	10,000 ASA	2.0	Ultra high speed, high contrast. 10-sec development.
	413	200–800 ASA	2.1	High contrast. High speed. Infrared sensitive. 15-sec development.
3¼ × 4½ Pack Films	107	3,200 ASA	1.3–1.4	Same as Type 47.
	108	75 ASA		Same as Type 58.

* Films compared in this study.

range of light density (proportional to different counting rates) is to be recorded on the same exposure, film of low gamma must be used so that low activity is recorded and high activity does not overexpose the image.

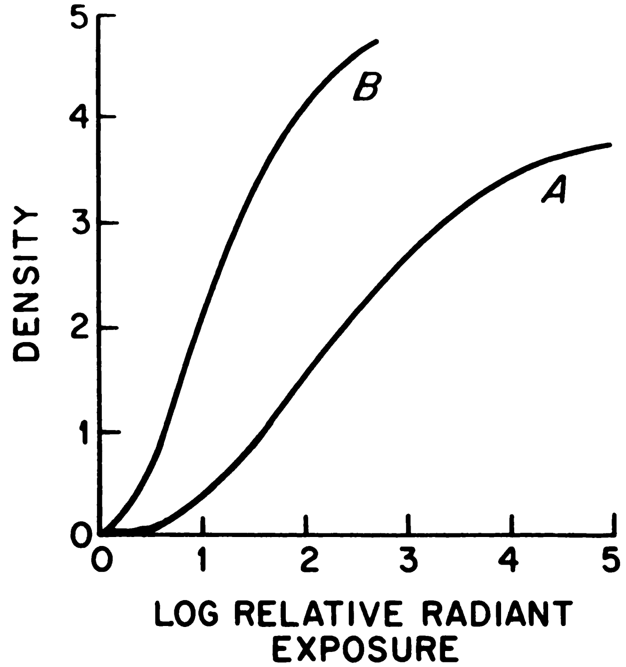

FIG. 2. Plot of film density as a function of log of relative radiant exposure for two films with different gamma values. Film gamma values are determined by maximum slopes of curves. Gamma for Films A and B are 1.25 and 3.0, respectively.

To determine which of these factors is important for selecting film for scintiphotography, we subjected four Polaroid film types to a variety of tests.

METHODS AND MATERIALS

The types of Polaroid film currently available are listed in Table 1 along with their package format, ASA rating, gamma and a brief description of their properties. The films compared in this study are marked by an asterisk. The most commonly used Polaroid film in scintiphotography today is Type 107 which differs from Type 57 only in package format, print size and, to a small extent, film gamma. In all of our tests Type 57 and 107 produced identical results. We have used Type 57 so that all comparisons could be made with the same camera and lens systems, A scintillation camera (Nuclear-Chicago Pho/Gamma III) was used for radioisotope detection. Its CRT was fitted with a Tektronix oscilloscope camera C-27 using a Polaroid 4 × 5 Land Film Holder 500. The CRT with P-11 phosphor produces blue light at 4,500 Å. The following comparisons among the four film types were made: (1) image resolution of various isotope filled test phantoms; (2) the importance of film gamma in clinical scintiphotography; and (3) resolution of organ structure in a variety of pathologic states.

RESULTS

Each scintiphoto in the study contains 300,000 counts with only the camera f-stop and the oscilloscope beam intensity changed as shown in Table 2. Figure 3 shows four different film exposures of a Nuclear-Chicago Model 1708 test phantom filled with ^{99m}Tc-pertechnetate. Types 52, 55 P/N and 57 scintiphotos are all similar in detail and contrast. The Type 51 scintiphoto has appreciably more contrast between areas of high and low activity. No additional information is conveyed by the higher contrast, but the differences in activities within the various regions of the phantom are more sharply defined.

In Fig. 4 the scintiphotos represent a wedge phantom with a sloping bottom so that the ^{99m}Tc-pertechnetate solution within the phantom is 1 in. deep × 1 in. wide at the small end, sloping 12 in. to the larger end which is 6 in. deep × 6 in. wide. Once again, Types 52, 55 P/N and 57 are all qualitatively similar. However, Type 51 is the only scintiphoto that accurately reflects the gradual increase in depth of solution toward the larger end. The corona of activity at the larger end is due to an edge effect inherent in the crystal detector of the scintillation camera. With the higher film contrast, the gradual increase in activity is better appreciated and in this case additional information is added.

TABLE 2. CAMERA AND OSCILLOSCOPE SETTINGS FOR POLAROID FILM COMPARISONS

Film type	f-stop	Oscilloscope intensity*
51	5.6	540
52	4.5	550
55 P/N	4.5	700
57	8.0	530

* Range = 0–1,000.

Figure 5 shows the same comparison made with scintiphotos of a brain tumor visualized with ^{99m}Tc-pertechnetate. The same information is contained in all of the films but is more sharply contrasted in the Type 51 scintiphoto. The same degree of contrast can be achieved by using closed-circuit television which is frequently employed for contrast enhancement of photoscans (*1*). In Fig. 6 a television camera was trained on the Type 55 P/N scintiphoto shown in Fig. 5. The photograph at the right was taken from the television monitor with no contrast enhancement. The center and left hand photographs

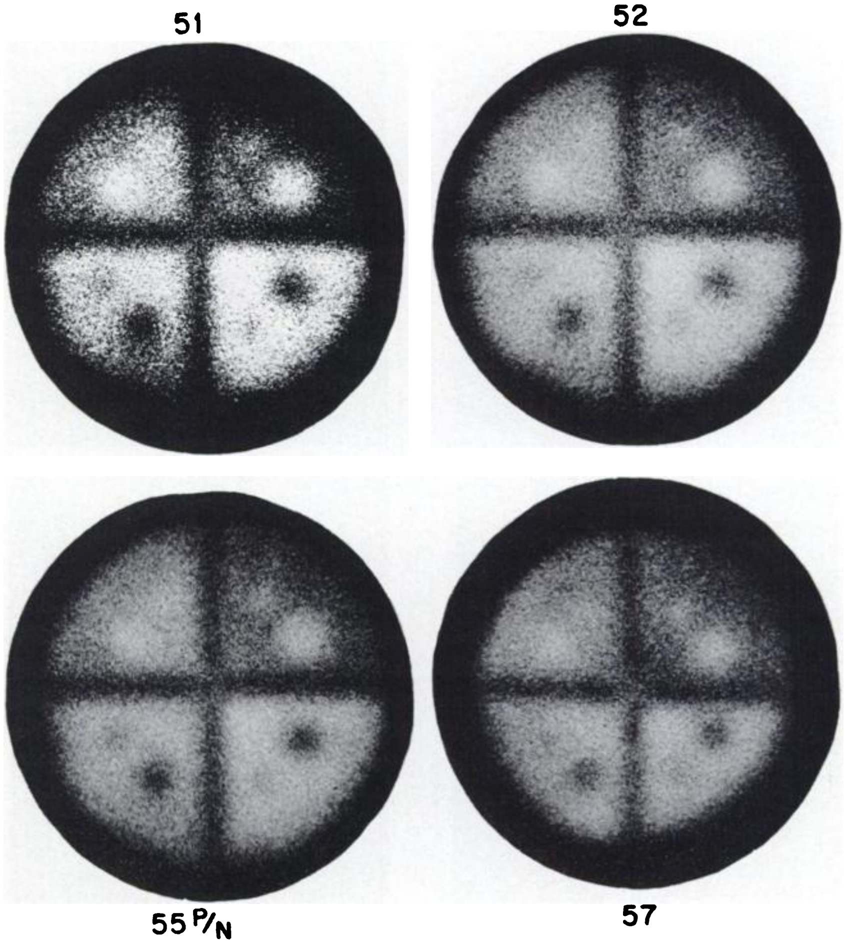

FIG. 3. Four Polaroid film exposures of Nuclear-Chicago test phantom filled with ^{99m}Tc. Each scintiphoto contains 300,000 counts and was made with same lens system but with different settings as shown in Table 2.

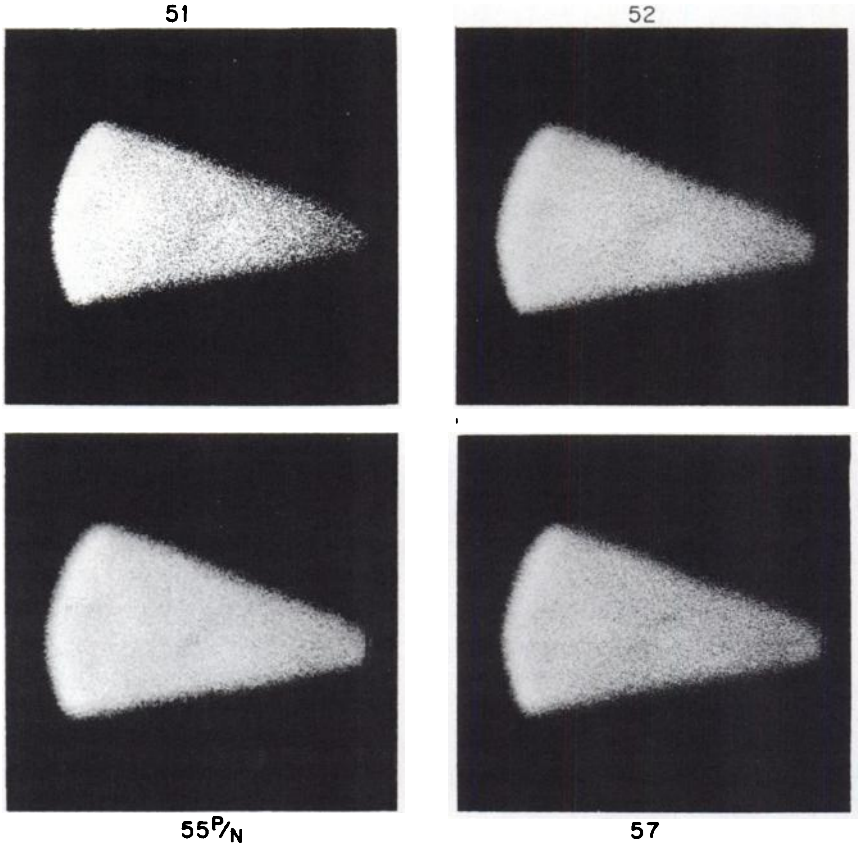

FIG. 4. Four Polaroid film exposures of wedge phantom filled with ^{99m}Tc. See text for description.

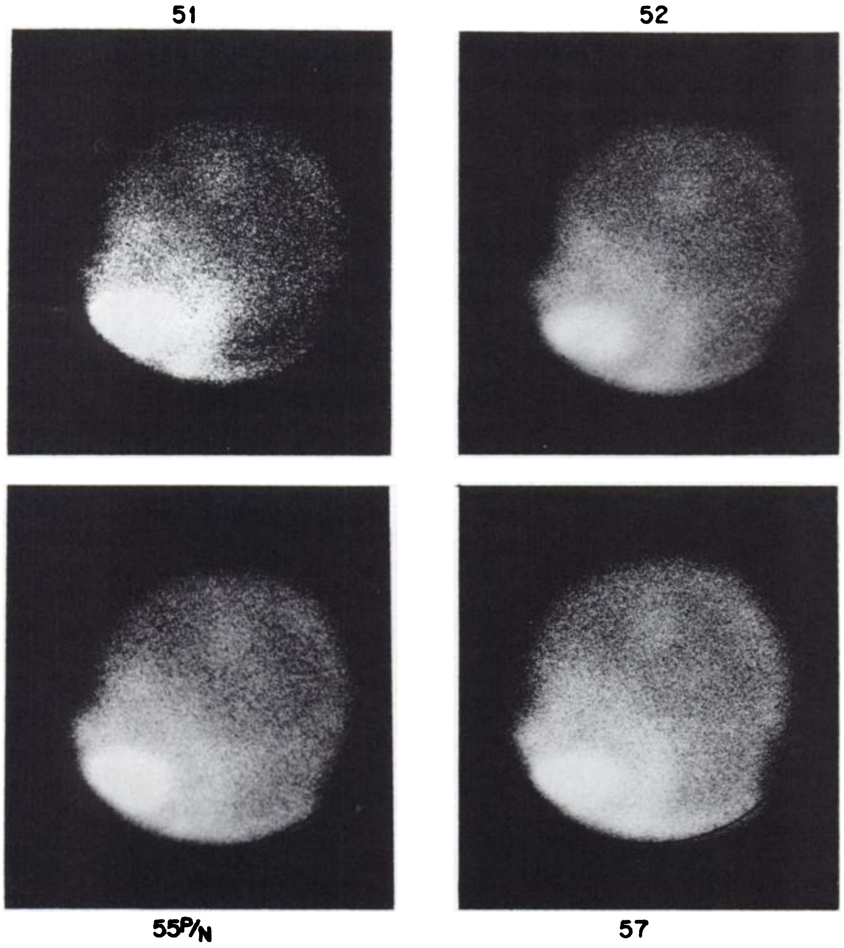

FIG. 5. Comparison of four Polaroid film exposures of brain tumor visualization with ^{99m}Tc. See text for description.

FIG. 6. Three photographs of television monitor showing successive changes in contrast demonstrating that effect of increasing film gamma can be duplicated in video system by altering monitor contrast adjustments.

were taken after successively increasing the contrast adjustment on the television monitor only. It is apparent that the same degree of contrast can be achieved with Type 55 P/N (as well as 52 and 57) after TV enhancement as is obtained by Type 51 film without manipulation.

DISCUSSION

High-contrast scintiphotos are easier to read because areas of differing activity are more sharply defined. In many cases, small differences in activity will not be detected except by high-contrast film or by using television contrast enhancement. If high-contrast film is used, it would be highly desirable to have a six lens cluster (*2*) rather than the standard three-lens arrangement on the Nuclear-Chicago camera. Film with high contrast can be over or under-exposed more easily than lower contrast film, and a wide range of f-stops will provide insurance against needless loss. This is made apparent in Fig. 7 which shows an array of three dishes (arranged vertically) containing 0.1, 0.4 and 1.6 mCi ^{99m}Tc. Each array is exposed at f-4.5, f-5.6 and f-8.0 using Types 51 and 57 films. With the low-contrast Type 57 film the lowest and highest concentrations are visualized on at least one f-stop setting without over or underexposing. With the high-contrast Type 51 film, the lowest concentration is never well visualized, while the highest concentration overexposes with a small change of f-stop. For this range of isotope concentrations which is well within the densities seen on ^{99m}Tc brain scans, more f-stops would be advantageous. Comparison of all four film types shows that 52, 55 P/N and 57 can record an activity range 5–6 times greater than Type 51 without overexposing. There is, however, an apparent expansion of the image size with increasing exposure that is inherent in all of the films.

At this point the distinction between contrast enhancement by means of film and background erase should be made. By closing the camera f-stop, and therefore admitting less light, background activity will become less apparent, accentuating areas of higher activity. However, the film-density separation between different light levels remains unchanged. To separate light levels, contrast must be enhanced by using higher gamma film. Figure 2 shows the relationship between film density and the log of relative radiant exposure for two films, A and B, with gamma of 1.25 and 3.0, respectively. It is readily apparent that film B will be more dense than film A with any given exposure. However, two areas of different exposure will be separated by a greater density difference for film B than film A.

The same kind of density separation is achieved on a television screen by adjusting the contrast setting. Electronically this increases the rate of beam-

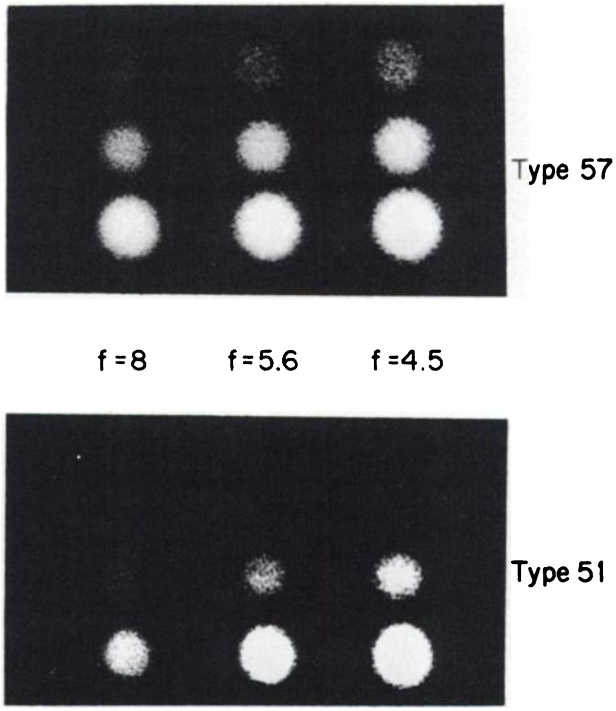

FIG. 7. Three dishes (arranged vertically) containing 0.1, 0.4 and 1.6 μCi ^{99m}Tc have been exposed for equal times at f-4.5, 5.6 and 8.0 using Types 51 and 57 films. Greater number of f-stop settings is required for high contrast Type 51 to display entire range of activity.

current response to the video signal, thus widening the difference between light levels.

We have concluded that film speed, at least over the 75 ASA–10,000 ASA range is not a crucial factor in film selection for static scintiphoto studies. Slower films require a lower f-stop to admit more light and/or increased CRT beam intensity. However, increasing the intensity with slow film does not make the dots larger or result in loss of resolution. In fact, we were unable to impair image resolution by increasing beam intensity well beyond the range necessary to expose the slowest of these films.

High-contrast film with a multiple f-stop lens cluster appears to be the best image recording system for organ visualization. At present, Type 51 is supplied only in the 4 × 5 format. It is expensive and far less convenient than the 3¼ × 4¼ film packs. The latter are essential for rapid hand-pulled studies such as cardiac blood flow and are currently supplied only in the low-contrast, high-speed, Type 107 film. Until the high-contrast film is supplied in another format, it will probably not invite wide use. With television contrast enhancement for occasionally ambiguous scintiphotos, Type 107 film is quite satisfactory. We have found, as have many clinical investigators in nuclear medicine, that increasing experience with any film gradually requires fewer additional visualization techniques. This is only the case, however, when all of the original information is recorded on the film.

ACKNOWLEDGMENT

The authors wish to thank Henry N. Wagner, Jr. and Jack D. Davidson for their helpful suggestions concerning this study.

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SECOND CALL FOR NUCLEAR MEDICINE ART EXHIBITS FOR 16TH ANNUAL MEETING IN NEW ORLEANS

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The Scientific Exhibits Committee is planning a nuclear medicine art exhibit open only to technicians (technical affiliates and associate members) who will display their best "works of art." This "art" may consist of normal and abnormal scans, scintophotos, renograms or other dynamic studies, etc.

All exhibits will be illuminated by available room light. There will be no provisions for transillumination, e.g. view boxes. Photographic prints or Polaroid film (black and white or color), any size, should be mounted on poster board not exceeding 30 in. × 30 in. No more than two boards may be entered for a subject. Exhibits should be clearly titled. Technical information related to the study displayed should be concise yet sufficiently detailed to instruct and assure duplication. Clinical information should be limited to details pertinent to the study. Technician's name and institutional address should appear at lower left corner. Prizes for the best exhibits will be awarded at the annual business meeting. The art will be judged on the basis of quality, presentation, originality and technical detail. Notice of intent to exhibit should be sent before May 1, 1969 to:

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