LOCALIZATION OF BRAIN TUMORS AT OPERATION WITH RADIOACTIVE PHOSPHORUS

AN IMPROVED TECHNIQUE USING A PROPORTIONAL COUNTER*

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The purpose of this paper is to describe the design, characteristics and
use of a newly developed proportional counter for the localization of
brain tumors at operation with radioactive phosphorus, P^{32}. The sub-
stitution of proportional for Geiger-Müller counting has made it possible to
construct brain-probing counters which are mechanically and electrically
superior to those that have been available.

The method of localization is based on the finding of Selverstone and
Solomon in 1947 that P^{32}, after intravenous injection, concentrated more in
intraocular tumors than in normal white matter by a factor of 5.5 to 112.† They proposed in 1948 the use of a “minute counter constructed after the
fashion of a ventricular cannula” for locating deep brain tumors.¹¹ Radio-
active phosphorus proved to be ideal for the purpose, since its pure beta
emission has an average range in tissue of about 1 mm. Research begun
elsewhere by Robinson and Peterson⁶ resulted in the development and
construction in 1948 and 1949 of suitable 3 mm. and 2 mm. beta-sensitive
G-M counters by Robinson,⁵ in collaboration with Selverstone. Subse-
sequently, successful use of the method was reported by Selverstone with
various collaborators,⁸,⁹,¹²,¹³,¹⁴,¹⁵ Morley and Jefferson,⁴ Garrity and Matthews,²
Schneider et al.,¹ and Matera et al.³ Using the standard Robinson-Selver-
stone, 2 mm. G-M probing counter‡ and P^{32} injected intravenously, a positive
test with tumor-to-brain activity ratios of 5 or more has been obtained in 96
per cent of a series of 232 operations for brain tumor.** Most of our failures
occurred in those few cases in which a glioma was so diffuse that no normal
control area was exposed for probing, or in which injection of P^{32} had been
inadvertently delayed until just before operation. Possibly because we are

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Service.
† A study of the mechanism of this differential uptake of P^{32} has been made by Selverstone and
Moulton,¹⁰ by measurement of specific activities of tissue fractions. Steinberg and Selverstone¹⁶ have
studied the distribution of P^{32} in tumors and brain by autoradiography.
** In 84 additional cases, radioactive potassium, K^{42}, has been used alone or with P^{32}, with similar
results.¹⁵,¹⁶ Radioactive sodium, Na^{24}, proved to be valueless, since it did not concentrate in tumors.¹⁶,¹²
so well acquainted with the design and use of the 2 mm. G-M probes, these have not been a cause of failure in our series. There have been complaints, however, from competent users, that some of the counters were fragile and relatively short-lived, so that difficulties occurred in the routine use of the method.\footnote{1}

Although we have found the performance of the standard probing counters to be generally satisfactory for localization of tumors, occasional serious limitations in their use have been encountered because of the relatively great lengths of their sensitive regions and insensitive tips (8 mm. and 7 mm., respectively; Fig. 1C). We are reporting here the development and use of a proportional probing counter whose sensitive region is only 2 mm. long, and is located at its extreme tip (Fig. 1A). It is sturdier and longer-lived than the G-M probe. Its construction presents no unusual difficulties; one of us (C.V.R.) has built 7 of the new probes, of which 2 have been in use for more than a year.

**DESCRIPTION**

The new counter (Fig. 2) is similar in external appearance to the G-M probe. The cathode of the counter is a shell of stainless steel, 0.06 mm. thick and 2.1 mm. in diameter, with a conical end (total apex angle=82°) whose point is slightly rounded (Fig. 3a). The anode (Fig. 3b) is a loop, 0.7X1.3 mm., of 0.007 mm. tungsten wire, mounted in a 0.25 mm., cupro-nickel tube. Fig. 3c shows the anode in air with a high voltage applied. The resulting corona-discharge is confined to the end-portion of the loop which coincides with the beta-sensitive region of the counter.

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**Fig. 1.** Scale drawings of the ends of the new and standard probe counters and of a No. 14 ventricular needle. The shaded areas represent the parts that are sensitive to the beta-rays of P\(^{32}\). The broken lines show the approximate volume of tissue counted by each probe.