We have equations for beta- and/or gamma-emitting nuclides, using an activity distribution geometry of either a spherical shell or volume geometry, or a combination of either, which allows calculation and prediction of dose to both cyst wall and deeper tissues. The equations have been incorporated into a computer program written by us. The output of the program is (1) dose, (2) dose rate, and (3) activity to be prescribed for a given desired absorbed dose as a function of distance and cyst size.

This computer program (written in BASIC on a CP/M based microcomputer) is available from the authors, and will shortly be offered for distribution on floppy-disk media through the services of the Radiation Shielding Information Center, Oak Ridge, Tennesse.

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**REPLY:** The approach we have taken to dosimetry has been that of Loevinger et al. (*1*), the "20,000 rad" calculated as being delivered to the cyst wall is an approximation based on certain defined assumptions. All dosimetry is an estimation of actual absorbed dose and, in fact, a tool used to correlate the administered dose in $\mu$Ci with clinical response. Thus, our calculated absorbed dose may in fact only be an index of the absolute radiation dose delivered. However, it is a clinical index which is meaningful in that Wycis et al. (*2*), Leksell et al. (*3*), and Backlund (*4*), using a similar calculation of cyst wall beta dosage, have shown that optimal long-term clinical response occurs between 10,000 and 40,000 rad. How much more meaningful McGuire et al.'s approach is, is hard to establish as in the paper of Balachandran et al. (*5*), only one patient with no long-term follow-up is described while the other paper (McGuire EL, et al: *Br J Radiol:* accepted for publication) is unavailable for examination at the present time.

We agree that the dose delivered is very dependent on the assumed distribution of the colloid in the cyst. Based on limited data we have acquired from serial cyst aspirations via indwelling cannulae, the degree to which phosphorus-32 ($^{32}P$) is adsorbed to the cyst wall is highly variable and we have taken the position that, as this parameter is in most cases undefinable, uniform distribution will be assumed to yield what should probably be better described as a minimum cyst wall dose of 20,000 rad. The question of the degree to which radiocolloids adsorb to cyst lining is controversial; with some workers observing this (*2, 6*), and others not (*4*). Our results have been variable and it is probably important to note that the composition of the cyst fluid may well influence the behavior of the colloid and that it may be unwise to extrapolate from the behavior of colloids other than $^{32}P$ [for instance gold (*6*) or ytterium-90 ($^{90}Y$) (*4*)].

With regard to the question of radiation dose at distances through the cyst wall, we believe that the moderate penetration of $^{32}P$ represents an advantage over the more penetrating radiation of $^{90}Y$. Thus, 3 mm represents the 85th percentile distance for $^{32}P$, the distance within which 85% of the energy is absorbed. Thus, as noted in (*5*), the dose outside the cyst wall to surrounding tissues at a depth of 2 mm would be low. However, as noted by other workers (*3,7,8*) consideration must be given to the absorbed dose to surrounding critical structures when they are in very close approximation to the cyst (e.g., the optic chiasm). It is important to note that the side effects described have been with gamma emitters (*3*) and with the more penetrating beta emitter $^{90}Y$ which has a 95% percentile distance of 6 mm as compared with 4 mm for $^{32}P$. In the case of side effects described from $^{32}P$ (*8*), this followed the administration of 5 mCi $^{32}P$ which the authors calculated to have delivered 100,000 rad to the cyst wall and 10,000 rad to the closely adjacent nerve, the cyst wall being only 0.5 mm thick. Thus, the cyst wall dose exceeded anything we have attempted. Nevertheless, it does indicate the need for caution in the case of cysts with very thin walls which are in close proxmity to critical structures.

Not having the elegant software available to McGuire et al. we have used the method of Loevinger et al. (*1*) as a first approximation and await publications of the technique which assumes a spherical shell model (McGuire EL, et al: accepted for publication), although reserving some doubt as to the behavior of $^{32}P$ colloid in different cysts. Until the question of distribution of $^{32}P$ colloid in the cyst can be solved for all cases, it is safe to say that the true absorbed radiation dose lies between that derived from a model assuming uniform radiopharmaceutical distribution in the cyst fluid and one in which all activity is rapidly adsorbed to the cyst wall. In either instance it is essential to correlate the clinical response to apparent radiation dose delivered.

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## Phosphorus-32 Therapy of Cystic Brain Tumors

**TO THE EDITOR:** The article by Taasan et al. (*1*) describes a technique which has considerable promise in the treatment of cystic brain tumors through the stereotactically directed placement of phosphorus-32 ($^{32}P$) colloidal chromic phosphate directly into the tumor. Because reports of this therapy are relatively limited, we would like to bring to the attention of the readership our confirming experience. The details of our technique are described elsewhere (*2–4*).

Stereotactic surgery for $^{32}P$ intracystic tumoricidal irradiation was performed in an operating room equipped with a dedicated high resolution computed tomographic (CT) scanner. Initially technetium-99m sulfur colloid dilution technique was used in six patients to confirm that CT measurements correlated with sulfur colloid measurements; the mean difference being 0.5%.

Following surgical trephination in each of ten (six female, four male) patients (eight with cystic craniopharyngioma, two with cystic astrocytoma in the region of the third ventricle) using a frontal burr hole placed at the region of the coronal suture, stereotactic puncture of the cyst was performed and the $^{32}P$ was administered. Twenty five thousand rads was selected as our target dosage to the cyst wall. Cyst volumes ranged from 2.8 to 80 ml.

All of the patients in our series have had initial favorable outcomes after $^{32}P$ implantation. This was demonstrated by regression in tumor size and an improvement or stabilization of neurological, visual, and endocrinological deficits. Follow-up evaluation (CT, opthamological, endocrinological) has ranged from 6 to 36 mo (mean of 18.6 mo). All patients had CT evidence of gradual cyst regression from 2 to 8 mo after surgery. All eight patients with craniopharyngiomas had stabilization of endocrinological function. One patient subsequently required craniotomy for resection of a solid craniopharyngioma component resulting in progressive optic chiasm compression. Visual deficits improved in eight of ten patients. Both patients with cystic astrocytomas have suffered recurrent solid tumor growth and ultimately expired.

We have found that stereotactic $^{32}P$ intracystic irradiation is a safe and effective treatment for selected benign and malignant neoplasms of the brain promoting slow reduction of cyst size over 1 to 15 mo after irradiation at surgery. We believe it should be considered as the primary treatment for solitary cystic craniopharyngiomas and as an adjunctive paliative treatment for cystic gliomas.


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**REPLY:** We are happy to note that Drs. Levine et al. have experienced satisfactory responses in the majority of the ten cases they have treated; the period of follow-up being significantly longer than ours at the time of publication. Their finding of very close agreement between cyst volume determined by technetium-99m sulfur colloid dilution and computed tomographic (CT) measurement is of interest as omission of the dilution study simplifies and shortens the procedure. However, caution should be exercised in that certain cases may have septa not visualized by CT dividing the cyst