



**FIGURE 1**  
Blood pool image showing patchy uterine activity with focal area of hyperemia to right of midline

subsequent blood-pool images. The blood-pool images were positive in all cases, including four women who had amenorrhea for 2–7 mo. None of the four women was pregnant at the time of the study. One woman was taking tamoxifen. Of the remaining 23 women, two were taking estrogen. The intensity of uterine activity was variable and did not correlate with time of menstruation. Activity was not always discrete and midline (Fig. 1).

Clinicians should be familiar with the varied patterns of the uterine blush on the early phases of the bone scan to prevent confusion with soft tissue inflammation and inflammatory bone disease.

#### Reference

1. Mandell GA, Harcke HT, Sharkey C, et al: Uterine blush in multiphase bone imaging. *J Nucl Med* 27:51–55, 1986

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**REPLY:** We appreciate the opportunity to comment upon the additional observations on uterine blush proffered in the letter to the editor by Segall and Gurevich. Their blood-pool images demonstrated characteristic supravescical activity in all menstruating women in their population with a mean age of 29.8 yr. Our population, mean of 20.1 yr, exhibited similar findings. The discordant blood flow and blood-pool images

they describe in six instances could possibly be related to their technique. Our blood flow images were acquired as 24 5-sec images vs. their 15 3-sec images. The lack of recognition of the uterus on the blood flow images in some of their patients could be attributed to the variation in statistics. Our images lasted longer (5 sec vs. 3 sec) and duration of blood flow segment of the study was greater (120 sec vs. 45 sec).

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#### Dosimetry for Cystic-Type Tumors

**TO THE EDITOR:** Taasan et al. have presented data which further illustrates the possibilities for radiopharmaceutical treatment of cystic type tumors (1). However, as in most cases previously reported, there appear to be some fundamental considerations which should be more completely addressed in order to deliver appropriate therapy. It would appear obvious that, in order to evaluate the effects of therapy to the cyst itself, the effect must be related to the dose delivered to the cyst wall. In Taasan et al. the radiation dose strived for is the dose to the inner surface of the cyst wall, which they give as 20,000 rad [as calculated by a formula given by Loevinger (2)]. In order for the dose to the inner surface of the cyst to be meaningful, though, one must assume that the energy of the beta emissions is completely absorbed in the wall. We have shown that a more meaningful descriptor of the dose relationship is the dose as a function of depth in the wall (3, 4), since there may be significant penetration of the beta particle outside the wall where it is thin (3mm in certain cystic tumors). The dose delivered is also very dependent upon the distribution of the radioactivity inside the cyst. We have noted, as have others previously (5,6), that after a short time most of the radiocolloid apparently tends to be "plated out" onto the inner surface of the cyst. Thus, rather than making the assumption of a uniform distribution inside the cyst fluid, the more appropriate geometrical configuration of activity for dosimetry purposes is the spherical shell geometry. With regard to the calculated dose to be delivered, we feel that the expected dose should be computed at distances through the wall, and some points beyond the wall if necessary, until the range of the beta particle is reached. The endpoint consideration should thus include both cyst wall dose as well as the surrounding tissue dose. The cyst wall thickness can be determined with modern imaging techniques (computed tomography or nuclear magnetic resonance).

The need for preciseness in the delivery of the dose has been demonstrated by reports of possible partial visual impairment (7–9) resulting from intracystic radioactive sources which can occur because of the frequent close proximity of the optic nerve of the adjacent cyst wall.

Equations and graphs to compute the desired dose as a function of distance in the cyst wall have been described in our recent articles (3,4). The spherical shell model given for phosphorus-32 (4) gives similar results to the infinite plane model originally proposed (3).

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, Tennessee.

#### References

1. Taasan V, Shapiro B, Taren JA, et al: Phosphorus-32 Therapy of cystic grade IV astrocytomas: Technique and preliminary application. *J Nucl Med* 26:1335-1338, 1985
2. Loevinger R, Japha EM, Brownell GL: Discrete radioisotope sources: I. Beta-radiation. In *Radiation Dosimetry*, Hine, Brownell, eds. New York, Academic Press, 1956, pp 694-754
3. Balachandran S, McGuire EL, Flanigan S, et al: Bremsstrahlung Imaging after  $^{32}\text{P}$  Treatment for residual suprasellar cyst. *International Journal of Nuclear Medicine and Biology* 12:215-221, 1985
4. McGuire EL, Balachandran S, Boyd CM: Radiation dosimetry considerations in the treatment of cystic suprasellar neoplasms. *Br J Rad* (Accepted for Publication).
5. Bond WH, Richards D, Turner E: Experiences with radioactive gold in the treatment of craniopharyngioma. *Journal of Neurol. Neurosurgical Psychiatry* 28:30-38, 1965.
6. Wycis HT, Robbins R, Spiegel-Adolf M, et al, Studies in stereoencephalotomy III. *Confin Neurol* 14:193-202, 1954
7. Leksell L, Backlund EO, Johnsson L: Treatment of craniopharyngiomas, *Acta Chir Scand* 139:237-247, 1967.
8. Kobayashi T, Kageyama N, Ohara K: Internal irradiation for cystic craniopharyngioma. *J Neurosurg* 55:896-903, 1981
9. Strauss L, Sturm V, Georgi P, et al: Radioisotope therapy of cystic craniopharyngiomas. *Int J Radiat Oncol Biol Phys* 8:1581-1585, 1982

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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  $\mu\text{Ci}$  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 ( $^{32}\text{P}$ ) 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  $^{32}\text{P}$  [for instance gold (6) or yttrium-90 ( $^{90}\text{Y}$ ) (4)].

With regard to the question of radiation dose at distances through the cyst wall, we believe that the moderate penetration of  $^{32}\text{P}$  represents an advantage over the more penetrating radiation of  $^{90}\text{Y}$ . Thus, 3 mm represents the 85th percentile distance for  $^{32}\text{P}$ , 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  $^{90}\text{Y}$  which has a 95% percentile distance of 6 mm as compared with 4 mm for  $^{32}\text{P}$ . In the case of side effects described from  $^{32}\text{P}$  (8), this followed the administration of 5 mCi  $^{32}\text{P}$  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 proximity 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  $^{32}\text{P}$  colloid in different cysts. Until the question of distribution of  $^{32}\text{P}$  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 radio-pharmaceutical 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.