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In vitro and *in vivo* Radioautography in Recognition and Localization of Gastric Cancer.* (25833)

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Malignant neoplasms have been shown to take up a greater amount of radioactive phosphorus than does normal tissue(1,2). Initial studies with *in vitro* radioautography provided the basis for extending the use of this property of radioactive phosphorus to clinical detection of occult gastric malignancy by a method of *in vivo* radioautography. *In vitro* radioautographs were obtained of 25 resected gastrointestinal specimens following intravenous administration of 500 μc P32, 12 to 24 hours prior to surgery in patients with suspected carcinoma of the gastrointestinal tract. The excised organ, directly following removal, was opened in its long axis and the mucosal surface was washed with saline solution. In a dark room, the excised tissue was then placed on an 8 by 10″ x-ray film with the mucosal surface down and separated from the film by a piece of Saranwrap to prevent moisture from the specimen affecting the photographic emulsion. Care was necessary to smooth out all mucosal folds so that only a single thickness of the mucosa was exposed to the x-ray film. The film and specimen were then placed in a black lined box and retained in the refrigerator for 12 to 16 hours, following which the x-ray film was developed. Malignant neoplasms consistently produced a black area signifying increased radioactivity (Fig. 2). Confirmation of the black areas as owing to the malignant lesion was obtained by super-imposing each specimen on the developed film. Benign ulcers demonstrated a lighter area than normal mucosa, thus suggesting a lower P32 uptake of that lesion than in adjacent healthy tissue (Fig. 1). Correct positives were noted in all 18 gastric, colonic, or rectal cancers and correct negatives in the remaining 7 cases. There were no false positive or false negative results except for area of early polypoid hyperplasia adjacent to gastric carcinoma which presented a false positive (see arrow, Fig. 2).

Methods and materials of in vivo *radioautography.* Patients with suspected gastric malignancy or with precursor conditions, such as pernicious anemia or achlorhydria, were given 500 μc of radioactive phosphorus in the form of sodium phosphate orally, 12 hours prior to study. A thin latex balloon (condom) coated on the inside surface with a highly sensitive photographic emulsion† on an elastic latex-base and attached to a No. 14 French nasogastric tube was then passed into the stomachs of these patients, inflated with air to about 600 ml, left in place for 6 hours, then removed and developed. A blackened area on the balloon denoted proximity of the photo-sensitive coated balloon to an area which had an increased uptake of radioactive phosphorus, indicating probable presence of a malignant tumor (Fig. 3).

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† Eastman Kodak Co., Rochester, N. Y.

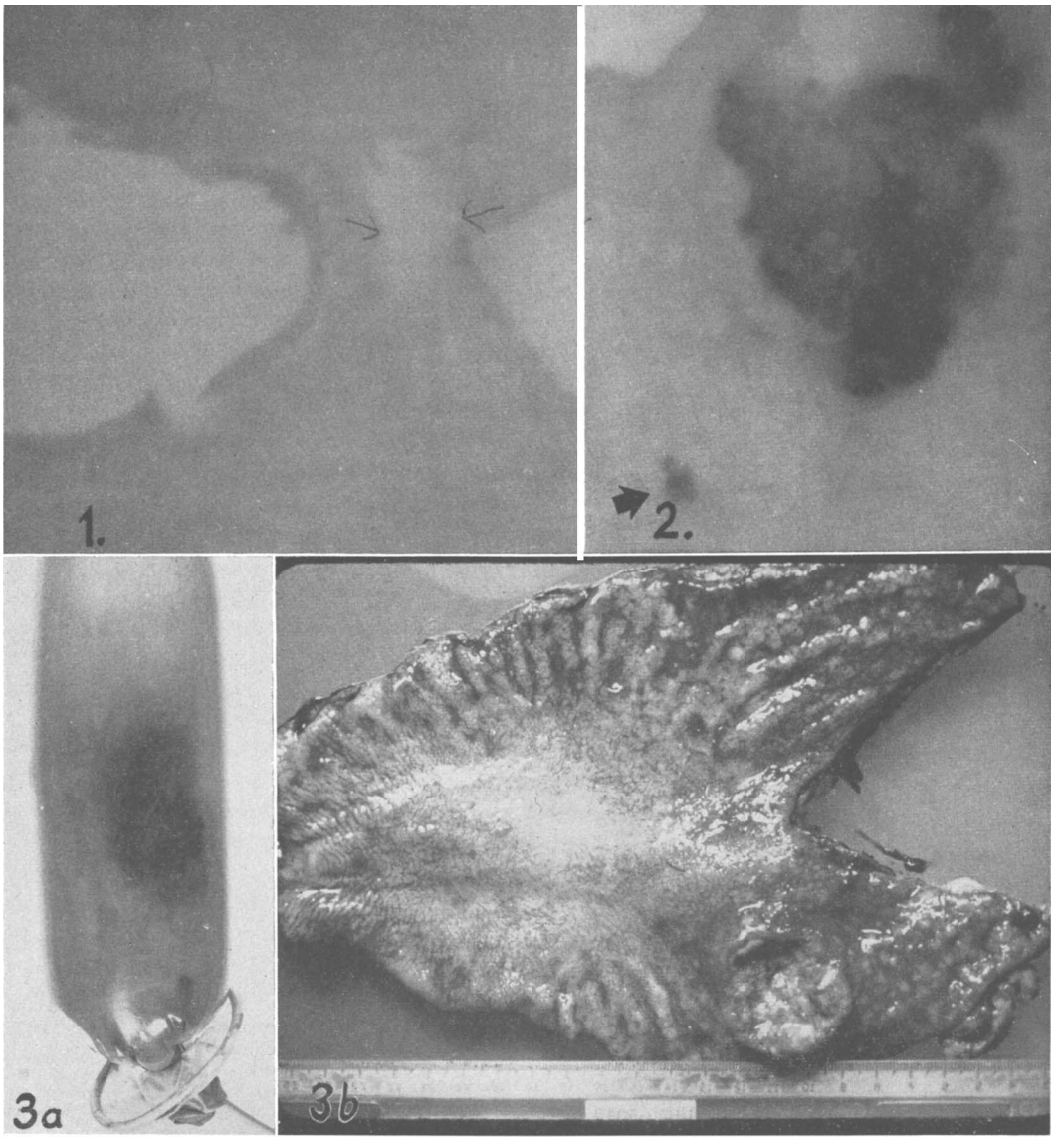

FIG. 1. *In vitro* radioautograph of gastric ulcer with punched out crater—usual finding in benign gastric ulcer.

FIG. 2. *In vitro* radioautograph of a large gastric cancer (dark area). Arrow points to area of polypoid hyperplasia.

FIG. 3a. *In vivo* radioautograph of a patient with gastric cancer. X-ray studies were also positive for gastric cancer.

FIG. 3b. Resected stomach showing malignancy.

Results. Two groups of patients have been screened: 1. A symptomatic group of 18 patients; 2. An asymptomatic group of 40 gastric cancer precursors. This latter group includes 11 patients with pernicious anemia, 5 with gastric polyps, 2 patients with hypertrophic gastric rugations, and 22 patients with long-standing achlorhydria on histamine stimulation. In none of the asymptomatic groups of patients was any suggestion of malignancy uncovered by *in vivo* radioautography. It is proposed to rescreen these patients once a year by the same means.

In the symptomatic group, of 7 patients

found at operation to have microscopically verified gastric cancer, all gave evidence on development of the photosensitive balloons of having a gastric malignancy by *in vivo* radioautography. In 6 of the 7 patients a correct preoperative roentgen diagnosis of malignancy was made. In 4 of these 6 patients repeated x-ray studies were necessary to establish the presence of a lesion. In the remaining patient, the roentgen diagnosis was benign ulcer; the malignancy in this patient was correctly identified preoperatively by *in vivo* radioautography.

Two additional symptomatic patients, by roentgenographic examination, were diagnosed as having gastric cancer; however, *in vivo* radioautographs were consistent with benign gastric disease. Both, at operation, were found to have normal stomachs with cancer in adjacent organs.

Of 11 symptomatic patients with benign gastric ulcer studied, 9 were diagnosed by the radiologist as benign; one lesion, erroneously diagnosed as gastric cancer by *in vivo* radioautography, was not observed on roentgen study; in the remaining patient, the radiological impression was that the lesion was probably malignant. This patient had a negative *in vivo* radioautograph. At operation a benign gastric ulcer was found and excised. Of these 11 patients with benign gastric ulcer, *in vivo* radioautography was unequivocally negative in 7 instances, definitely positive in 1, and questionable in 3.

Discussion. Roentgen studies, the best available diagnostic agency in recognition of gastric cancer, have limitations. X-ray studies have been notably disappointing, moreover, in detection of early asymptomatic mucosal gastric cancers. Inasmuch as the success of *in vivo* radioautography is contingent solely upon the greater affinity of cancer for radioactive P32 over that of the contiguous normal gastric tissue, there is good reason to believe that *in vivo* radioautography will come to supersede x-ray studies in detection of silent mucosal gastric cancer.

In punched-out gastric ulcer craters, devoid of gastric mucosa, *in vivo* radioautographic studies have been consecutively negative. The false positives have been observed in healing gastric ulcers. The presence of an actively regenerating tissue may be responsible. This aspect of the inquiry needs further elucidation. Neither in the atrophic gastritis of pernicious anemia nor in patients with hypertrophic gastric rugae were areas of increased absorption of radioactive P32 observed with *in vivo* balloon radioautography.

It is believed that this same technic with minor alterations can be extended to include examination of other organs such as the cervix, rectum, breasts, and prostate, thus permitting multiple screening from one tracer dose of radioactive phosphorus.

Conclusion. 1) A technic of *in vivo* gastric radioautography is described, employing a balloon (condom) coated with a photosensitive emulsion. Its use in recognition of gastric cancer is outlined. 2) The method served to identify correctly and uniformly the presence of gastric malignancy. There have been no false negatives. The only false positives observed have been in healing gastric ulcers; the nature of this discrepancy needs to be resolved by a larger experience and continued study of the problem.

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