RADIATION SAFETY INFORMATION REGARDING BODIES CONTAINING RADIOACTIVE METASTRON®

Metastron is a radiopharmaceutical ($^{89}SrCl_3$) that is used to relieve pain caused by bony metastasis resulting from breast, prostate or lung cancer. The strontium is a calcium analog and will therefore be taken up by osteoblasts at the site of the bone cancer. The radiation from the strontrium-89 will kill tumor cells in the immediate vicinity of the strontium, thereby relieving pain.

Some Facts about Strontium-89

- Half-life of 50.5 days (after each 50 days the radioactivity level is reduced by ½).

- Pure beta particle emitter of energy 1.463 MeV (beta particles are very easily absorbed, their maximum range in tissue is approximately 8mm).

- One of the radiation safety advantages of Strontium-89 is that it presents a very small, if any, external radiation hazard. Because of the beta particle's low energy and range the radiation emitted by strontium is absorbed by:

    1. itself (self absorption)

    2. the air between the strontium and one's body

    3. the body's external layer of skin (which is dead).

  This means that if the Strontium-89 is outside of (external to) one's body the radiation hazard is very slight.

- Strontium-89 only becomes a radiation hazard if a sufficient quantity is deposited within the body, either by ingestion or inhalation (this is an internal radiation hazard). In this way the living tissues within the body that are in contact with the strontium are irradiated.

The 4ml volume of Metastron® that is administered IV contains only 4 mCi and is considered a relatively small quantity of radioactivity (there are diagnostic studies that use activities several times higher than this). Within 7 to 10 days after administration 20% of the radioactivity has been excreted via the urine and feces. The remaining 80% enters the calcium metabolic cycle. Studies have shown that after 100 days, as much as 20% to 80% of the original strontium is still bound to bone. It appears that the more widely spread the bony metastasis are, the higher the retention rate.

The expected life span of these individuals has been shortened significantly due to their disease. The pain relief benefit of Metastron® is usually not realized until 1-2 weeks after the injection; therefore, this treatment is not given to moribund patients. While some individuals treated may continue to live years beyond the administration of Metastron®, it is expected that even the most seriously ill patients given this treatment will live many months after the time of administration. Whether the patient dies a few days or a few years after the administration of Metastron® the question is raised: **What radiation hazards does the body of the deceased present?** Disposition of the body either by burial or by cremation will be discussed.

The deceased is interred in a tomb or buried in a grave.

If the individual has died more than 10 days after the administration of Metastron® there is an insignificant radiation hazard. Any body fluids removed will contain very little radioactivity and these fluids may be disposed of in the routine manner. Because strontium is bound to the bone and its range in tissue is limited to 8mm there is no external radiation emitted from the body, i.e. no radiation will be detected around the body. Radiation precautions are not necessary in any phase of the burial process.

If the individual has died within 10 days of the administration then Radiation Safety personnel may want to store any body fluids removed for decay or disposal.

The deceased is cremated

When the body of the deceased is cremated, the shielding provided by the soft tissue is removed as the tissue is vaporized in the retort. Most of the radioactivity remaining in the body is located at the bone – soft tissue interface. Because of this, much of the strontium is vaporized with the soft tissue (in one documented case, 65%) and is then exhausted into the atmosphere along with the huge

volume of air that passes through the exhaust system during each cremation. The large volume of air dilutes the radioactivity to well below permissible levels allowed for the atmosphere and presents no hazard to the general public or to mortuary staff.[2] Thus only a small fraction of the radioactivity is in the ash and bone fragments that are left in the retort and presents no external hazard. However, inhalation and/or ingestion of large quantities of the airborne ash may exceed permissible limits of intake of radioactive materials. Of specific concern is the ash that is dispersed in the air in the area of both the retort and the pulverizor. This ash "dust" may be inhaled or ingested if masks and protective clothing are not used.

The American Institute of Hygiene states that a work area containing more than 10 mg/m^3 of particulate matter is an unacceptable environment for an unprotected worked exposed to an inert dust.[3] If a mortuary staff person is working in an environment at this threshold level for 1-1.5 hr per cremation and not using protective gear† then this individual must be limited to cremating less than 844 bodies per year.†† This is based on a ^{89}Sr inhalation limit of 13.5 μCi/yr recommended by ICRP 61[4]. Under the same working conditions, if breathing protection were supplied, but ash was allowed to be deposited on the worker's skin, ingestion would be a hazard. In this case, for ingestion alone, the worker would be allowed to conduct 5000 cremations per year.†† This is based on 89Sr ingestion limits of 8.1 μCi/yr recommened by ICRP 61[4].

The preceding may suggest that if the airborne dust levels are below a concentration of 10 mg/m^3 a protective mask and clothing is not necessary if the number of cremation per year is kept below the stated levels (844 cremations per year). **However, it is strongly recommended that protective gear is worn by staff and attempts are made to minimize the ash suspended in the air.** The ALARA concept (**A**s **L**ow **A**s **R**easonably **A**chievable) in radiation safety states that all reasonable attempts should be made to reduce radiation dose whenever possible. Wearing protective gear at all times will not only eliminate the internal disposition of the radioactive strontium, it will prevent inhalation of the dust for all cremations regardless of whether the body contains radioactive material.

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† Breathing mask and clothing which keeps the dust from being deposited on skin, hair and personal clothing.

†† See appendix

APPENDIX

Breathing Rate

A normal breathing rate is 0.36 m^3 in one hour. In conservative estimation assume the consumption of 1 m^3 of air in 1.5 hours. This will also account for the fact that the respiration rate will increase with some exertion.

Ingestion

At a level of 100 $\mu gm/cm^2$, skin contamination may not be visible and thus may not be immediately removed by washing. In previous work, it has been assumed that a person will ingest all of the contamination from 10 cm^2. This assumes that 100 μgm/cm2 x 10 cm^2 = 1 mg of ash per day is ingested.[2]

Maximum Activity Contained in Body

A maximum of 4 mCi is assumed. It will always be less than this amount (allowing for excretion and decay) and will likely be much less than this if the administration of the Metrastron® was several months before death.

Concentration of Bone Ash in the Air in the Vicinity of the Retort and Pulverizor

Assume that the concentration of ash in the air is at the American Institute of Hygiene threshold for a safe workplace which is 10 mg/m^3. It is not possible to know what this level is at each cremation facility without special equipment. It is, therefore, recommended that masks and protective clothing be worn for all cremations.

Activity per Gram of Ash

If one assumes that the mass of ash remaining in the retort is 2500 gm then the radioactivity concentration in the ash is 4 mCi ÷ 2500 gm = 1.6 $x10^{-3}$ μCi/mg.

Inhalation by Mortuary Staff

When one cubic meter of air is consumed in this previously defined dusty environment, a total of 10 mg of ash are inhaled. This represents 10 mg x 1.6 x 10^{-3} μCi/mg = 1.6 x 10^{-2} μCi per cremation ICRP 61[4] recommends that a non-occupationally exposed worker be limited to less than 13.5 μCi per year for inhalation of ^{89}Sr. This represents 13.5 μCi per year ÷ 1.6 x 10^{-2} μCi per cremation = 844 cremations per year.

Ingestion by Mortuary Staff

When 1 mg of ash is ingested, then 1 mg x 1.6 x 10^{-3} μCi/mg = 1.6 x 10^{-3} μCi per cremation. ICRP 61[4] recommends that a non-occupationally exposed worker

be limited to less than 8.1 μCI per year for ingestion of ^{89}Sr. This represents 8.1 μCi per year ÷ 1.6 x 10^{-3} μCi per cremation = 5063 cremations per year.

Radioactivity Remaining in the Retort and Pulverizor

Less than 1% of the ash remains in the retort. The amount of radioactivity remaining in the retort is 4000 μCi x 0.01 = 40 μCi. This represents a very small amount of radioactivity which would be difficult to detect since this 40 μCi would be spread throughout the retort. It is not a radiation hazard. Very little of this would be incorporated into the subsequent cremations-it is highly likely that it would not be detectable, even with the most sensitive instruments. Less than half of the ash remaining in the retort would be left behind in the pulverizor (< 20 μCi). This represents no radiation hazard to mortuary staff. An insignificant amount of radioactive strontium may be incorporated into cremains processed at a later date.

1. Private Communication
2. "Individual and Collective Doses From the Release of ^{89}Sr into the Environment Following Medical Administration," J.R. Cooper, et. al, National Radiological Protection Board, United Kingdom (1989)
3. American Conference of Governmental Industrial Hygienists, TLVs (Threshold Limiting) for Chemical Substances in the Work Environment, Cincinnati (1986).
4. ICRP-61, Annals of the ICRP Publication 61: Pergammon Press, "Annual Limits on Intake of Radionuclides by Workers Based on the 1990 Recommendations" (1991)