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From: Burrows, Ronald
Sent: Tuesday, August 24, 2010 5:13 PM
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Subject: Emailing: REACT.TS Internal Contam presentation see UO4.ppt
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REACT.TS Internal Contam presentation see UO4.ppt

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Subject: Emailing: REACT.TS Internal Contam presentation see UO4.ppt
Sent Date: 8/24/2010 5:13:24 PM
Received Date: 8/24/2010 5:14:24 PM
From: Burrows, Ronald

Created By: Ronald.Burrows@nrc.gov

Recipients:
"Burrows, Ronald" <Ronald.Burrows@nrc.gov>
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MESSAGE	346	8/24/2010 5:14:24 PM
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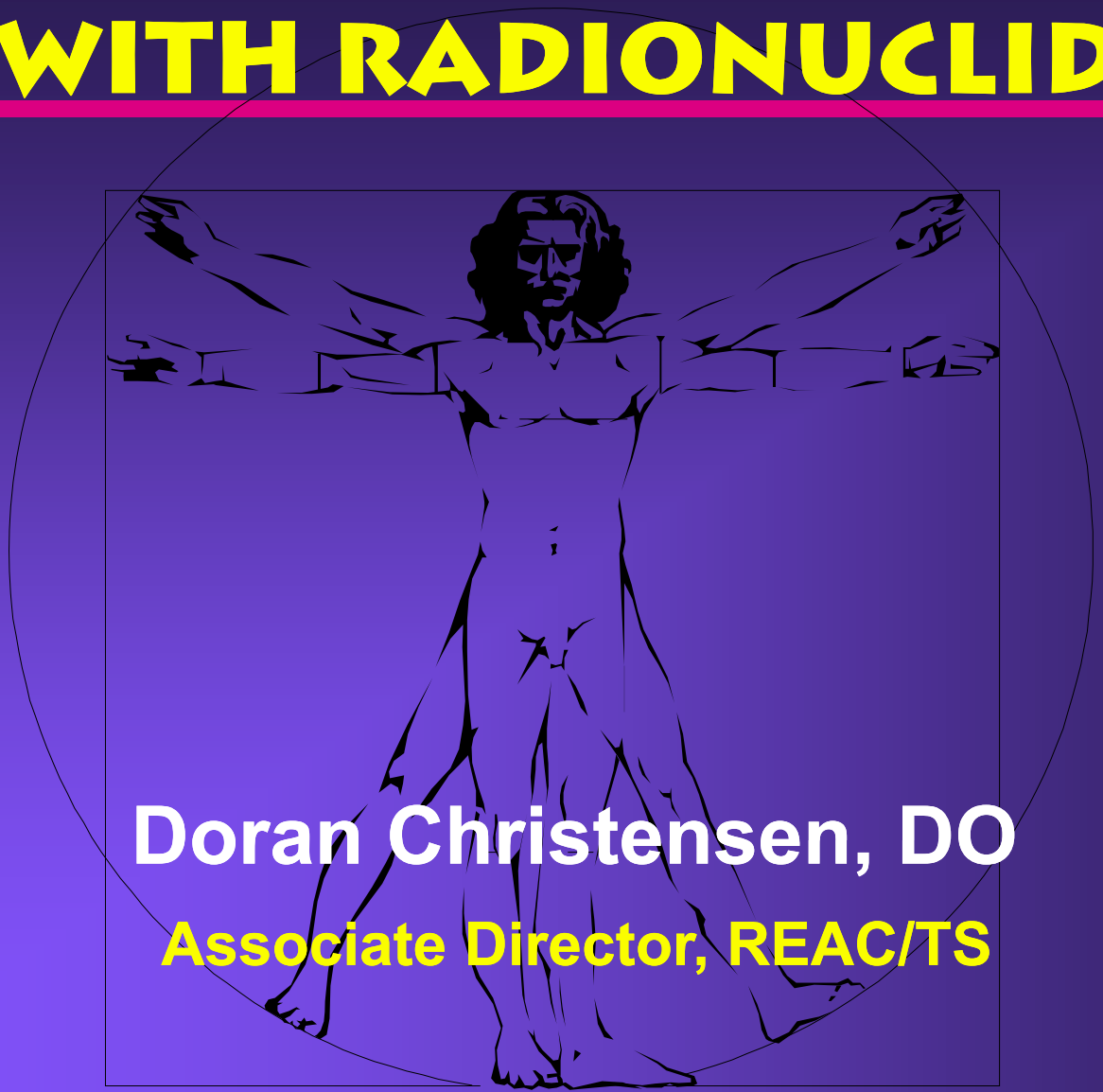
ATMENT FOR INTERNAL CONTAMINA WITH RADIONUCLIDES



Doran Christensen, DO

Associate Director, REAC/TS

OBJECTIVES

- Understand Principles of Incorporation
- Know Action Levels for Treatment
- Know Five Most Common Types of Internal Contamination

4 GOLDEN RULES OF TOXICOLOGY

(Adapted from Kent Olson, MD FACEP)

- Treat the Patient before the Poison
- Prevent or Reduce Exposure
- Enhance the Elimination of the Agent
- Consider Specific Adjuncts

ANNUAL LIMIT OF INTAKE

The derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. ALI is the smaller value of intake of a given radionuclide in a year by the reference man that would result in a committed effective dose equivalent of 5 rems(0.05 sievert) or a committed dose equivalent of 50 rems (0.5 sievert) to any individual organ or tissue. (see 10 CFR 20.1003.)

POSE TOXICOLOGY PROBLEMS

- The Dose makes the Poison
- Acute (Threshold Effects)
- Long-Term Toxicity
- ALI / MPBB

[1]

< 1 ALI	- No Treatment Necessary
1 - 10 ALI	- Consider Short-Term Tx
> 10 ALI	- Treatment

[1]Radiation Protection Dosimetry, Vol 41, No 1, 1992, p. 25

SAMPLE ALIS

Radioisotope	ALI-Ingestion (mCi)	ALI-Inhalation (mCi)
^{3}H	80	80
^{14}C	2	2
^{32}P	0.6	0.6
^{33}P	6	8
^{35}S	10	20
^{125}I	0.04	0.06

Source – Princeton University, Environmental Health & Safety

PSYCHOLOGICAL ASPECTS OF INTERNAL CONTAMINATION

- Radiation Exposure Sometimes Continues Long after Accident
- Estimates of Dose and Effects are distressingly Variable even among Experts

RADIONUCLIDES VS. OTHER HAZARDOUS MATERIALS

- Easily Detectable
- Use Health Physicist Instead of Industrial Hygienist
- Does not Require Special Clothing for Health Care Providers
- Not an Immediate Life-Threatening Hazard
- Can Wait until Patient is Stable before Decontamination

USE YOUR MEDICAL OR HEALTH PHYSICIST

- Document Presence of Radionuclides, Activity, Accident Details
- Collect Samples Documenting Contamination
- Assist in Decontamination Procedures
- Calculate/Document Dose Calculations
- Dispose of Radioactive Waste

BIOASSAY IS OF LIMITED VALUE

- Slow (Days)
- Must Have Total Collection of Both Urine and Feces
- Can Overestimate Uptake by Factor of 3 -5
- Specimen May Get Contaminated

WHOLE BODY COUNTING DIFFICULT WITH ACTINIDES

- Residual Skin Contamination
- Calibration of Phantoms Deficient
- Lung Distribution Varies with Time
- Variable Thickness of Sternum / Chest Wall

TOXICOLOGIC PROBLEM: (GATHER DATA)

- Details
  - Radionuclides Involved
  - Laboratory License
  - Maximum Credible Exposure
  - Geometry, Distances, Times
- Potential for Exposure
  - Poison Control Analogy

HOSPITAL RESOURCES

- Radiologist or Nuclear Medicine Physician
- Medical or Health Physicist
- Radiation Safety Officer (RSO)
- Nuclear Medicine Decontamination Area
- Nuclear Medicine Gamma Camera

HOSPITAL NM GAMMA CAMERA FOR SELECTED INTERNAL CONTAMINATION

Radionuclide	WBC (MDA in air)	Gamma Camera (MDA in air)	G-M Survey Counter Scatter Media (MDA in air)	
^{125}I		030-2.62	3.68-29.90	90
^{201}Tl	0.20	0.51-0.69	2.40-3.48	188
^{99m}Tc	0.09	0.37-0.39	1.15-1.53	144
^{111}In	0.12	0.40-0.56	1.36-1.64	165
^{133}Ba	0.11	0.71-0.89	1.88-2.50	20
^{131}I	0.12	0.56-1.09	1.51-2.71	59
^{85}Sr	0.11	0.68-0.99	1.85-3.22	90
^{137}Cs	0.13	1.04-2.26	2.47-4.03	59
^{54}Mn	0.10	1.06-1.84	2.70-4.24	38
^{60}Co	0.10	1.27i-1.48	2.11-3.15	14

EXTERNAL RESOURCES

- State Radiological Health Department
- Radiation Emergency Assistance Center / Training Site (REAC / TS) - 865 / 576-1005
- CHEMTREC (for HazMat components only) 800 / 424-9300

OTHER EXTERNAL RESOURCES

- Agency for Toxic Substances Disease Registry (ATSDR) 24 Hour Line
  404 / 639-0615 (No Answer)
- Dept Of Energy (DOE) Emergency Operations Center
  24 Hour Line 202 / 586-8100
- Nuclear Regulatory Commission (NRC)
  24 Hour Line 301 / 816-5100
  301 / 951-0550

INTERNAL CONTAMINATION RAMIFICATIONS

- Isolation During Therapy?
- Follow-up for Possibly Long Periods
- Counseling for Carcinogenic Implications of Exposure

INTERNAL CONTAMINATION - INVOLVES 4 STAGES

- **Deposition** Along Route of Entry
- **Translocation**
- **Incorporation** (Deposition in the Target Organ)
- **Clearance**

PREVENTING INCORPORATION

- Interception Before Radionuclide Reaches Target Organs
- Decrease Body Uptake
  - Vomit / Lavage
  - Charcoal / Catharsis
  - Other Methods

CONSIDERATIONS IN TREATMENT FOR INTERNAL CONTAMINATION

- Chemical Toxicity of Substance
- Solubility (D,W,Y)
- Particle Size
- Quantity
- Half-life of Radionuclide:

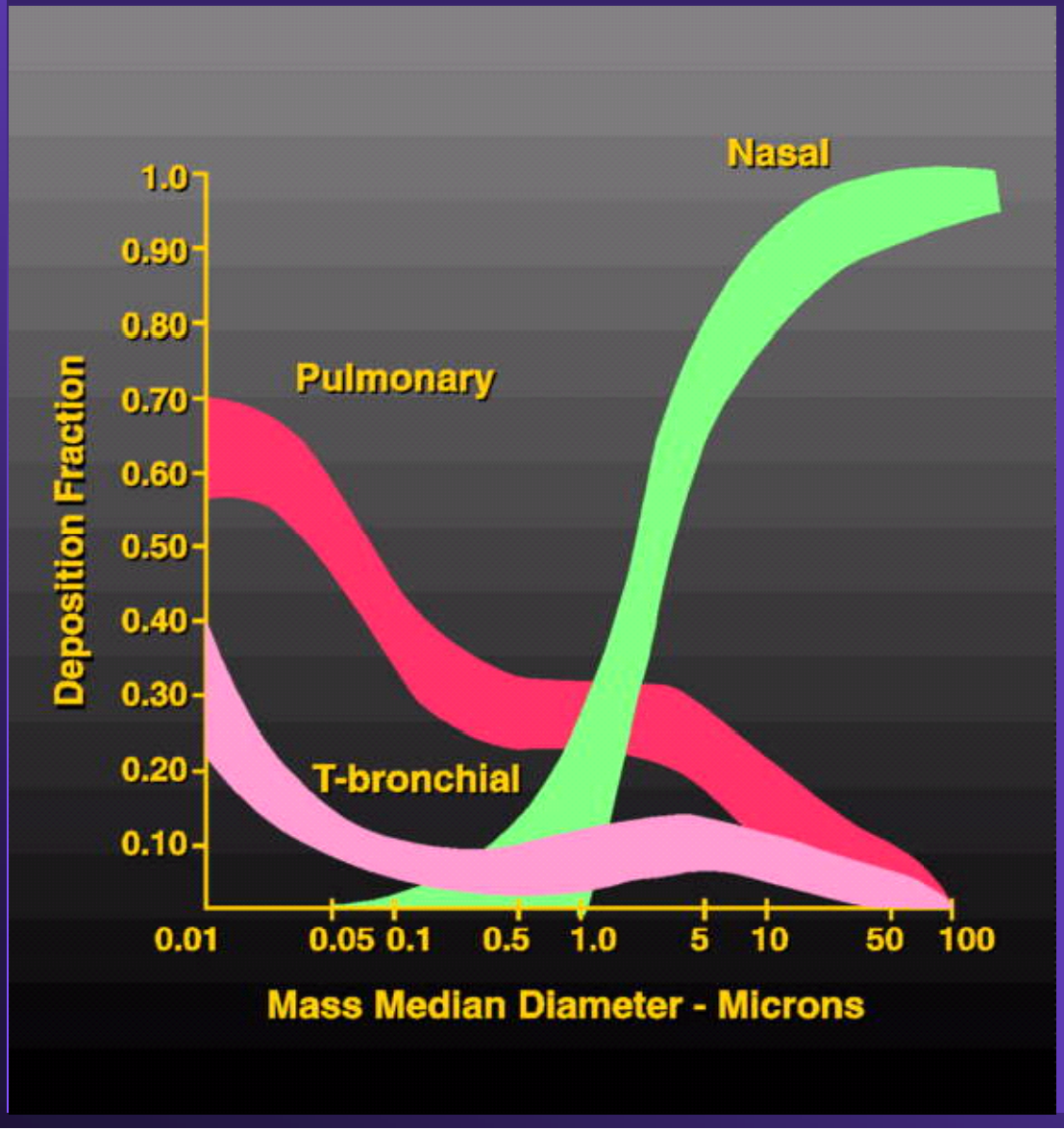
Physical + Biological → Effective

RESPIRATORY TRACT CLEARANCE TIME

Segment	Time (hours)
Anterior nare	1.0
Nasopharynx	0.1 (10 mm/min)
Trachea	0.1
Bronchi	1.0
Bronchioles	4.0
Terminal Bronchioles	10.0
Alveoli	100+ days

[1]ICRP #30 Model (1979)

PARTICLE SIZE AND DEPOSITION FRACTION



NASOPHARYNX CLEARANCE TIME

[1]

Anatomy	Clearance Time (min)
Anterior nare	60
Nasopharynx	10 (10 mm/min)

[1]ICRP #30 Model (1979)

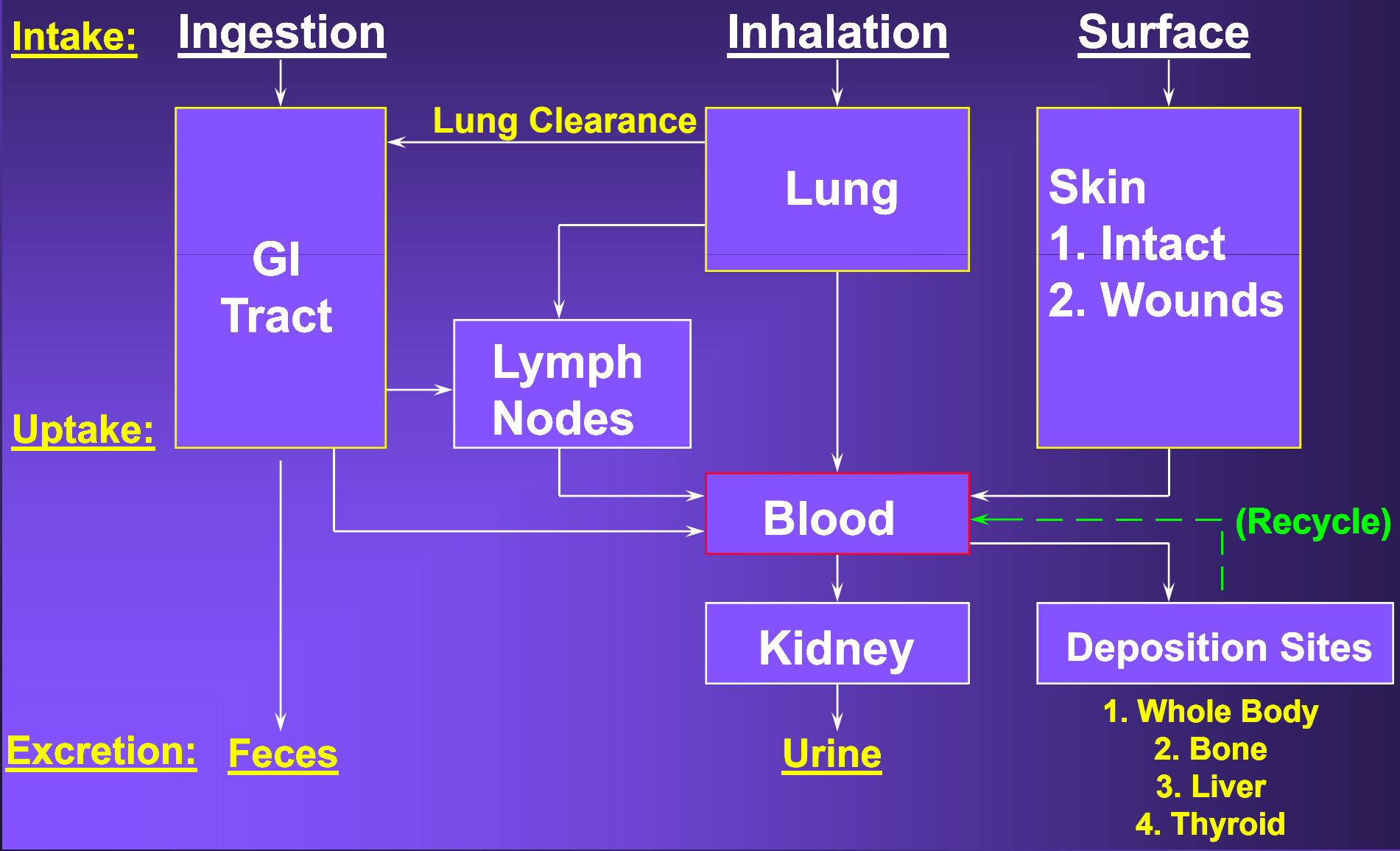
GASTROINTESTINAL TRACT RESIDENCE TIMES

[1]

Portion	Residence Time (hours)
Stomach	6 / 24
Small Intestine	14 / 24
Upper Colon	18 / 24
Lower Colon	24 / 24

[1]ICRP #30 Model (1979)
(Assumes Stable Substances)

SCHEMATIC MODEL OF RADIONUCLIDE UPTAKE (AFTER VOELZ)



TREATMENT OF INTERNAL EMITTE

- **TIME:** Within 3 hrs, if Possible
- **BENEFIT:** 2 to 10 Reduction of Organ Dose
- **RISKS:** Minimal, except for Lung Lavage / Some Drugs
- **DECISION:** Go to Potential Exposure History, Not Dose

PHYSIOLOGIC PRINCIPLES USED IN RADIONUCLIDE DECORPORATION

- GI Tract Removal / Enhanced Elimination
- Dilution of Isotope
- Displacement
- Blocking
- Alkalinization
- Chelation

REDUCTION/ABSORPTION FROM GASTROINTESTINAL TRACT

- Antacid
- Precipitation into Soluble Salt
- Catharsis

IODINE / TECHNETIUM - BLOCK

- ^{131}I - Eff Half Life = 7.6 days
- ^{99m}Tc - Eff Half Life = 1 day*
- Treat within 4 Hours
  (Best 1 Hour Before Exposure!)
- KI or NaI 300 mg tablet
- SSKI (1 g / ml) - 5 - 6 drops in water
- Povidone Iodine Theoretically Useful

NCRP Report No 65, p 83-86, 104

TRITIUM - DILUTE

- Beta Emitter
- 2% Binds to Cellular Components
- Essentially Occupies TBW Space
- Force Fluids 3 - 4 L / day
  - Reduces Half-Time by 1/3 - 1/2

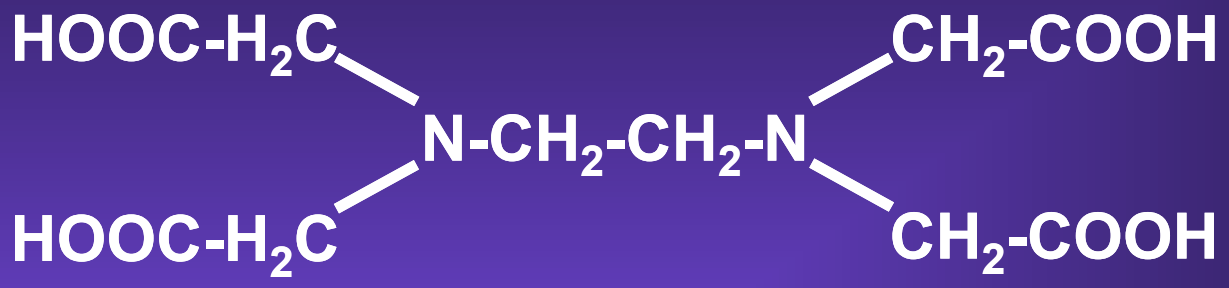
NCRP Report No 65, p 105-106

BEER THERAPY FOR TRITIUM

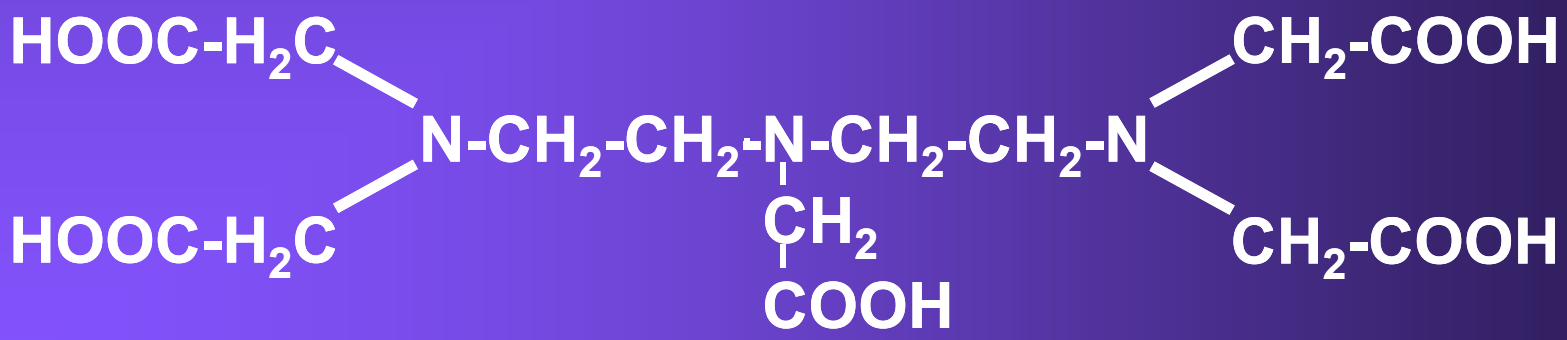
CHELATION AGENTS

- DTPA - Transuranics (not Uranium)
- EDTA - Lead (and others)
- BAL - Lead, Polonium, Gold, Indium
- DFOA - Iron, Manganese
- PCA - Copper, Lead, Mercury , Zinc, Cobalt, Gold
- DMPS - Mercury (not in US)
- DMSA - Lead (and Others)

COMPARISON OF EDTA AND DTPA



EDTA - Ethylenediaminetetraacetic Acid



DTPA - Diethylenetriaminepentaacetic Acid

DTPA Administered for Soluble ^{239}Pu Within One Hour

Organ	Retention	
	Control	DTPA Treated
Liver	14%	0.47%
Skeleton	57.0%	5.9%

Insoluble Prussian Blue Effective for Cs-137

- Binds Ions in the Gut
- Biological Half-Life Reduced to 1/3
- Not Systemically Absorbed
- Side Effects - Constipation,
  GI Upset at Higher Doses (20 g / day)

Lung Lavage

- Does Not Need to be Done Emergently[1]
  (3-5 days after Exposure)
- Lavage Technique for Pulmonary Alveolar Proteinosis
- For larger depositions 50[2] -100[1] ALIs
- Common Bronchoscopic Lavage
  (has not been evaluated for effectiveness)

[1]Radiation Protection Dosimetry, Vol 41, No 1, 1992, pp. 32-33.

[2]*Safety Series No. 47*, Vienna: IAEA, 1978, p 23.

Uranium Compounds and Solubility Classes

[1]

Compound	Solubility Class
UF_6 (Uranium Hexafluoride)	D
$UO_2(NO_3)_2$ (Uranyl Nitrate)	D
UO_3 (Uranium Trioxide)	D
UO_2Cl_2 (Uranyl Chloride)	D
UO_4 (Uranium Peroxide)	W
UO_2 (Uranium Dioxide)	W,Y
UC_2 (Uranium Dicarbide)	Y
UO_2 (High-Fired Uranium Dioxide)	Y

[1]Adapted From *Biokinetics and Analysis of Uranium in Man*, Hanford Environmental Health Foundation for the US Dept of Energy, 1984

Uranium in Biological Fluids

- pH 6.5 - 8 Principal / Most Easily Transported Form of Serum U is Biscarbonato Complex, $UO_2(CO_3)^{2+}$
  - Uranyl Citrate Complex also formed
  - Weak Complex of UO_2^{2+} and Iron-Transport Protein, Transferrin also Forms in Plasma

Adapted From *Biokinetics and Analysis of Uranium in Man*, Hanford Environmental Health Foundation for the US Dept of Energy, 1984

Uranium Deposition in Kidney

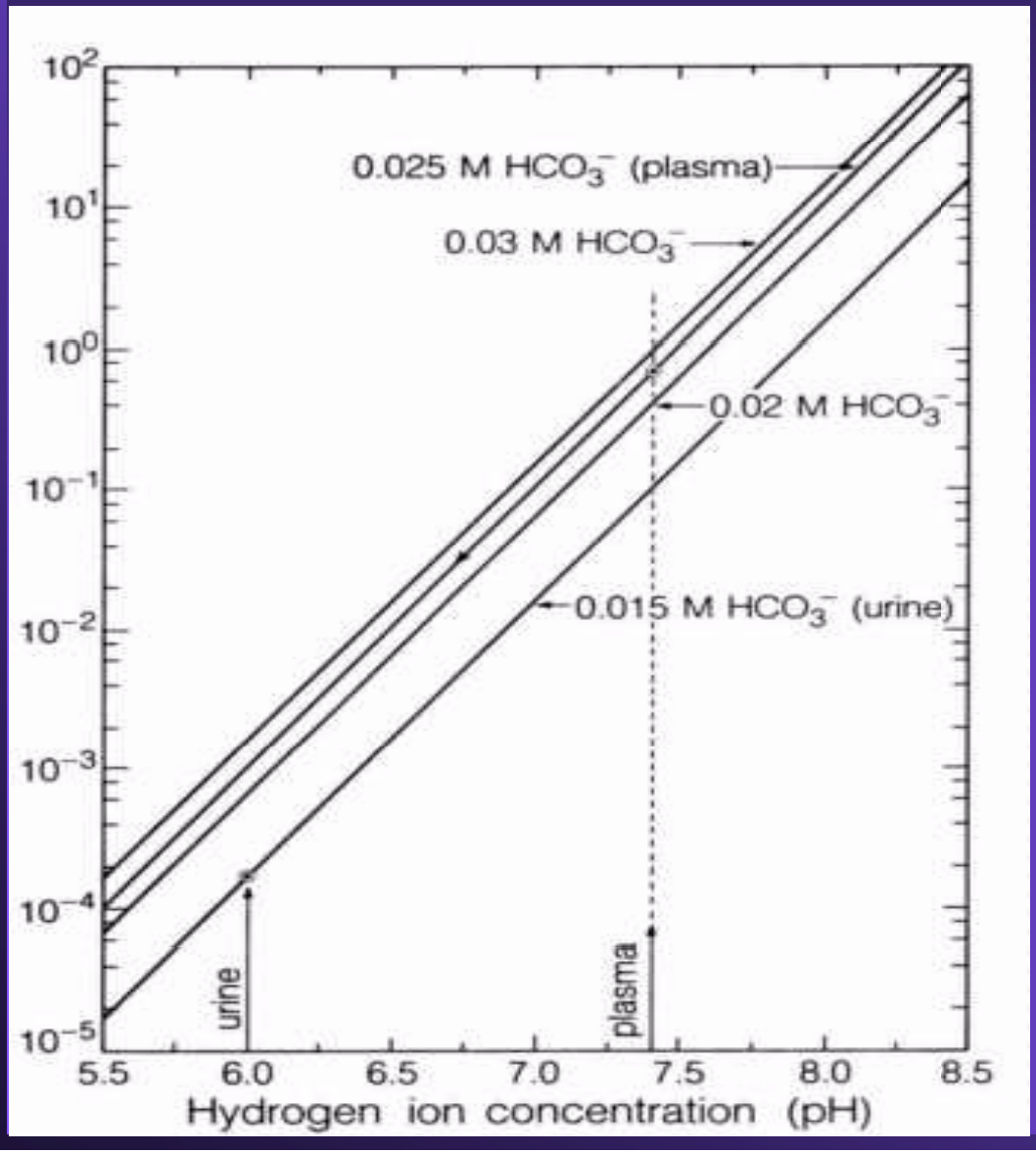
- Some of Bound UO_2^{2+} is Retained in Kidney
  Renal Retention Enhanced by:
  - Large Amounts of U
  - Acidic Urine
- U Kidney Release Half-time is 15 d
  Enhanced by Alkaline Urine

Adapted From *Biokinetics and Analysis of Uranium in Man*, Hanford Environmental Health Foundation for the US Dept of Energy, 1984

Uranium - Alkalinize Urine

- ^{235}U - Gamma
- Eff Half Time Depends on Solubility
- At Normal Enrichment Levels, Primary Renal Toxicity
- Maintain Urine pH 7.5 to 8
- Use Bicarbonate tablets
  (Do not use Alka Seltzer from old texts!)
- Use Supplemental KCl tablets to maintain alkaline diuresis

Uranium Solubility and Urine pH



- Alkalinzation recently called Questionable

References

NCRP 65 –
Safety Series #47 –
Radiation Protection Dosimetry, 1992
Radiation Protection Dosimetry, 2000

“I'm so happy doin' the neutron dance”

Pointer Sisters, 1990

Thank you!