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Biodosimetry of Plutonium Workers



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*“Learning from Plutonium and
Uranium Workers”*

Sixteen Papers Reviewed

- Mayak (6)
- Sellafield (4)
- Rocky Flats (2)
- Manhattan Project – UPPU (1)
- UKAEA (1)
- Semipalatinsk (1)
- Russian Nuclear Workers (1)



Early Papers

- G.W. Dolphin (1971)
 - 8 plutonium workers, who were exposed to:
 - Plutonium for 7 years, and
 - 14 rem external dose (average values).
 - Pu workers were compared to unexposed controls and externally exposed workers from Buckton et al.
 - Findings: any increase in dicentric chromosomes was attributed to external dose.
- Hemplemann et al. (1973) studied 25 UPPU club members (Manhattan project).
 - No excess chromosome aberrations were found.



Types of Assays

- Solid Stained
- G-banding
- FISH (fluorescence in situ hybridization)
- mFISH
- mBAND



Asymmetrical Aberrations

	Was an excess observed?	
Asymmetrical	Y - Tawn (1985, G-banding)	N - Whitehouse (1998, G-banding)
Unstable	Y - Okladnikova (2005, Romanovsky-Gimsa stain)	N - Whitehouse (2001, solid Giemsa stain) ^a N - Tawn (2006, FISH)
Dicentrics	Y - Tawn (2006, FISH) Y - Livingston (2008, FISH)	N - Dolphin (1971)
Acentrics	Y - Livingston (2008, FISH)	
Rings		N - Livingston (2008, FISH)

^a External dose not accounted for.

A significant excess of asymmetrical aberrations would imply that mature lymphocytes are being irradiated by deposited plutonium.



Symmetrical Aberrations

	Was an excess observed?	
Symmetrical	Y - Tawn (1985, G-banding) Y - Whitehouse (1998, G-banding)	
Stable	Y - Okladnikova (2005, Romanovsky-Gimsa stain)	N - Tawn (2006, FISH)
Translocations	Y - Livingston (2008, FISH)	N - Salissidis (1998, FISH) N - Tawn (2006, FISH)



Handling External Dose

- Significant external doses in most Pu-exposed workers
 - Median: 290 mSv Max: 3,300 mSv
- Most common : “external only” vs. “Pu + external”
 - Ideally, each group had the same level of external dose
 - Sometimes the “Pu + external” group had a higher external dose.
- Linear Regression
 - Regress the number of chromosome aberrations against body burden, red bone marrow dose, and/or external dose.



Regression Results

	External Dose	Body Burden (BB)	Red Bone Marrow (RBM)	Average Pu		Average External Dose	Comments
				BB (kBq)	RBM Dose		
Salissidis et al. (1998)	Y	N		9.1 ^a		3,300 mSv	
Burak et al. (2001)	Y	N		2.0		3,400 mGy	
Livingston et al. (2006)	N		Y		168 mSv ^b	280 mSv ^b	
Okladnikova et al. (2005)	Y	Y	Y	7.99		90 mGy	External correlation not found for stable aberrations.
Sotnik et al. (2011)	Y	Y	Y	2.05	120 mGy	1,000 mGy WB 860 mGy RBM	External correlation not found for intra-chromosomal aberrations.

^a midpoint of range

^b median

Note: Body burden and dose data are for the plutonium-exposed group (1-3) or the most highly exposed plutonium group (4-5)



Correcting for External Dose

- One study subtracted off the contribution from external dose (Tawn et al., 1985)
 - Asymmetrical aberrations
 - Assumed a 3-year half-life
 - The number of expected aberrations from annual external doses were estimated, and subtracted from the total number of aberrations.
- Results: An increase in aberrations with increasing plutonium deposition was observed.
- Subsequent studies by similar authors do not find an increase in asymmetrical aberrations.



Intra-chromosomal Aberrations

- Several papers indicate that intra-chromosomal aberrations are a biomarker for past exposure to densely ionizing radiation.
 - Mayak Worker Studies
 - Hande et al. (2003, mBAND/mFISH)
 - Mitchell et al. (2004, mBAND/mFISH)
 - Sotnik et al. (2011, mBAND/mFISH)



Conclusions

- Several studies have associated excess chromosome aberrations with incorporated plutonium.
- However, significant external radiation doses make it difficult to interpret these findings.



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Questions?

