PLUTONIUM AND AMERICIUM CONTAMINATED PUNCTURE WOUND - INITIAL TREATMENT, MONITORING, DOSIMETRY AND MEDICAL ASPECTS

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ABSTRACT

During post operative clean-out of a glove box, previously used for processing radioactive material, an operative sustained a puncture wound to the tip of the left ring finger. Following initial health physics and medical evaluation and treatment, monitoring, using a reverse electrode hyperpure germanium detector, estimated an Americium-241 wound content of approximately 9 Bq. After further cleaning by medical staff the wound was re-monitored and its activity had reduced by half. Wound monitoring was continued until all activity was removed from the wound site, by excision, eleven days post incident. Urine sample collection and analysis commenced immediately post incident and daily samples, analysed for the following 21 days, indicated a differential uptake of plutonium and americium from the wound site.

The paper summarises the health physics and medical aspects, consultation with the individual, monitoring of the wound site and associated materials, activity balance and uptake estimation from bioassay data.

INTRODUCTION

AWE has a number of facilities in various stages of decommissioning. This paper refers to a wound incurred in a facility that had ceased operational work and was undergoing post operative clean-out (POCO) prior to decommissioning. POCO tasks are carefully planned to optimise risks, but it is acknowledged that wounds can lead to significant internal dose commitment for decommissioning operatives. Hence procedures and personal protective equipment (PPE) are used to optimise the risks to personnel, utilising controls identified in the risk assessment for the task. Prior to any POCO documentation being produced a visual inspection of the glovebox is undertaken and this is used, with its operating history, details of radioactive material hold-up and the risk assessments (including PPE), to produce the Safe System Of Work for the task.

HEALTH PHYSICS AND MEDICAL CARE

During post operative clean-out of a glovebox, previously used for processing actinides, an individual sustained a puncture wound to the tip of the left ring finger. The individual was immediately aware that a ‘splinter’ had entered his finger and alerted health physics staff, whose initial monitoring indicated contamination at the wound site. The wound was bleeding and thus had the potential to wash some of the contamination out of the wound site. The wound area was contained prior to

evaluation and cleaning by medical staff. Nasal samples were taken from the individual concerned, and other personnel in the area, and counted along with their Personal Air Samplers. Health physics staff remained with the individual, providing monitoring, reassurance and information as required.

Initial medical treatment occurred in a dedicated facility designed for dealing with contaminated casualties. The aim of this initial treatment was to stop the bleeding, so that the wound site could be clearly seen and evaluated. All materials associated with the event and treatment of the wound (e.g. swabs, towels, etc.) were retained for monitoring, analysis and activity balancing. Once bleeding had stopped the individual was monitored in the AWE whole body monitor with a reverse electrode hyperpure germanium detector over the wound site. This indicated the presence of ^{241}Am at the wound site.

The results were discussed with the individual prior to further cleaning of the wound by medical staff. Wound monitoring, in the whole body monitor, then showed the activity at the wound site had decreased by half. Dressings were changed daily, with old dressings retained for monitoring and analysis. Wound monitoring continued, after medical assessment of the wound, on a regular basis. The lymph nodes associated with the wound site were also monitored.

Urine sample collection and analysis commenced immediately post incident (PI). Daily urine samples were collected and analysed for the following 21 days, before the individual returned to routine monitoring.

Following review of the initial data (d0-d6) by medical and health physics, consultation with the individual on the way forward resulted in the agreement that the remaining activity should be excised - this was done in AWE's medical facility eleven days PI. Prior to wound excision a series of measurements were completed using the hyperpure germanium detector, with a slit collimator 2 mm wide, to establish the location of the remaining contamination in the wound. This enabled the approximate location of the wound activity to be identified in an area some 2-4 mm deep, below the entrance wound and extending some 8 mm towards the tip of the finger. Monitoring of the wound site and excised tissue confirmed that all remaining activity was removed from the wound site by the excision.

MONITORING RESULTS

All PAS and noseblow results showed no evidence of an inhalation intake. Wound, tissue and other materials analysis results, with the time PI, are listed in Table 1. A depth of 5 mm was assumed in the estimation of activity at the wound site - given the depth estimation above, of 2-4 mm, the results quoted may over-estimate the activity at the wound site by approximately 10%. The dressings and swabs from medical treatment were all analysed, but many showed no detectable activity, Table 1 only includes those results that were above the detection threshold. The axillary and supra-trochlear lymph nodes, which drain the wound site, were monitored in the whole body monitor on days 0, 6 and 10 PI, no activity was detected (limit of detection 0.2 Bq ^{241}Am). The ^{241}Am in urine results are shown in Figure 1. The urine excretion data were interpreted using the Durbin[1] excretion function, which provided the best fit to

the bioassay data to estimate systemic uptake from the wound site and hence dose. The ^{241}Am uptake estimate is 3.2 Bq. In comparison the data for ^{239}Pu gave an uptake estimate of 0.2 Bq.

Time	**Wound site** [3]	**Other materials** [4] Bq		**Activity Balance** Bq
PI	^{241}Am Bq	^{241}Am	^{239}Pu: ^{241}Am	total ^{241}Am from wound
0 hrs		10.5 ± 8.1 [5]		
2 hrs	9.2 ± 1.1			
3 hrs		1.0 ± 0.3 [6]	8 ± 3 : 1	1.0 ± 0.3
3 hrs		3.8 ± 3.1 [7]		4.8 ± 3.4
4 hrs	4.6 ± 0.7			
4 d	2.4 ± 0.5	0.45 ± 0.25[6]		5.25 ± 3.65
6 d[1]	3.1 ± 0.6			
6 d[2]	3.1 ± 0.5			
10 d	2.7 ± 0.6			
11d	< 0.04	1.3 ± 0.51[6]	4.5 ± 1.5 : 1	6.55 ± 4.16

Notes:
1 - before medical cleaning of wound
2 - after medical cleaning of wound
3 - using reverse electrode hyperpure germanium detector
4 - using hyperpure germanium detector in low background cell
5 - gloves worn for POCO
6 - excised tissue
7 - swabs/towels

Table 1: Monitoring results

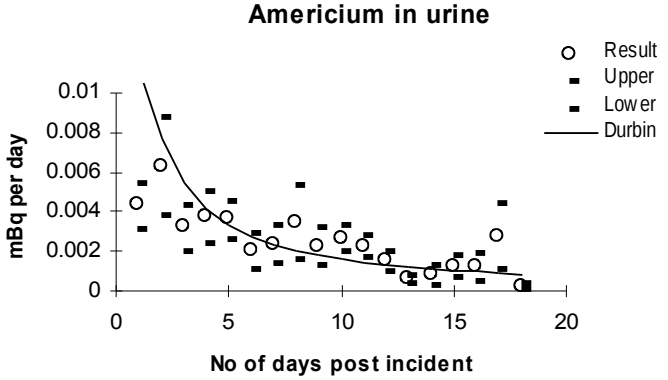

Figure 1: ^{241}Am excretion data and fit to Durbin excretion function.

ACTIVITY BALANCE

The sum of ^{241}Am in the material removed from the wound site, during medical treatment, and by uptake to blood, estimated from the urine excretion data, is approximately 10 Bq, however summation of the measurement errors gives a total error of 50% on this activity balance. The ^{239}Pu:^{241}Am ratios of the excised material concur with the varied components identified by analysis of the glove box contents.

Bioassay indicates that the ^{241}Am uptake occurred promptly, most probably due to a soluble Americium Chloride component present under the inert conditions of the glove box at the time of the incident.

As some of the uptake may have occurred before the wound site was initially measured, and with the errors associated with the wound and tissue sample measurements, definitive conclusions on the final activity balance cannot be reached.

CONCLUSIONS

The initial medical treatment reduced the measured ^{241}Am activity in the wound content by 50%, half of the remaining activity was then removed by further medical treatment and by rapid translocation of soluble ^{241}Am to blood during the first day post incident. The less soluble ^{239}Pu/^{241}Am remained at the wound site until surgically excised 11 days after the wound occurrence.

Rapid analysis of the samples identified the differential translocation of ^{239}Pu and ^{241}Am from the wound site and maintained an activity balance of material removed from the wound. This enabled prompt decisions to be made on the wound treatment and ensured that the dosimetry follow-up and investigation were completed within 3 months of the event.

Open discussion of the data with the individual, by medical and health physics professionals, enabled him to participate fully in the decision making process.

Following this incident the use of the germanium detectors, to estimate both the amount of plutonium in wound and the depth of activity, is being investigated. We are also assessing the possibility of using detectors in the whole body monitor to assess systemic uptake by direct monitoring immediately post incident, if soluble actinides may be involved in a wound incident.

REFERENCES

1. Durbin, P.W. (1972). Plutonium in man: a new look at the old data. In: *Radiobiology of Plutonium,* Stover, B.J. and Lee, W.S.S. (eds). The J.W. Press, Salt Lake City.

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