Abstract: Rapid assessment of radiation dose is essential to help guide the early steps of medical management. At least initially, it is not necessary to hone in on a precise number, but to determine the magnitude of the radiation dose. Whether the dose is delivered via internal contamination or external exposure, physicians need to make the decisions about the potential biological effects associated with the radiation dose received by the patient so that determinations about whether to treat or not, what type of treatment may be needed, the level of acuity, etc., can be made. Good communications and cooperation between the responding health physicists and medical care personnel are necessary for proper medical response to an incident involving radioactive materials.

1. Introduction

Individuals who have been involved in radiation incidents must receive proper evaluation and medical care. Physicians and other medical care providers must obtain a quick estimate of the radiation dose in order to prepare the medical treatment plan. The initial information need not be overly technical or precise, but it needs to be easily obtained and able to provide a realistic magnitude of the radiation dose [1].

Patients must be made aware of what is transpiring, and the risks must be clearly and effectively communicated to them as well as to their physician. The risks associated with radioactive materials are often misunderstood. While the risks resulting from an exposure or contaminating event can be quite significant to the patient, it is exceedingly rare that, if managed properly, the physician is at significant risk.

Various techniques can be employed to help gather the necessary information in a timely and effective manner. Evaluation of nasalswabs and wound counts can help with determining the potential for significant intakes of radioactive materials, and mathematical dosimetry estimations can help with determining the potential magnitude of external doses. In conjunction with a good event history and other data, health physicists and physicians can develop a strategy for providing proper initial medical care to individuals. Biosurvey results, timing and severity of radiation induced injuries or illnesses, contamination and holding, etc. will likely provide more detailed dose information. However, these techniques take time and create a delay that may be detrimental to effective early medical intervention [2].

2. Tools for Dose Assessment

(a) Derived Reference Level (DRL):

Wounds can be initially assessed via the use of the DRL. The DRL, expressed in disintegrations per minute (dpm), reflects the amount of contamination in a wound that should result in an effective dose of 50 mSv or a committed organ dose of 500 mSv. DRLs are described for various compounds and are expressed related to their residence at the wound site (weakly, moderately, strongly, or avidly bound) [2, 3].

Table 1. DRLs for Selected Radioisotopes in dpm

<table>
<thead>
<tr>
<th>Isotope</th>
<th>Based on*</th>
<th>Weak</th>
<th>Moderate</th>
<th>Strong</th>
<th>Avid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cs-137</td>
<td>ED</td>
<td>1.54E+08</td>
<td>1.54E+08</td>
<td>1.65E+08</td>
<td>2.01E+08</td>
</tr>
<tr>
<td>Sr-90</td>
<td>BS</td>
<td>2.20E+07</td>
<td>2.20E+07</td>
<td>2.25E+07</td>
<td>2.38E+07</td>
</tr>
<tr>
<td>Ge-68</td>
<td>ED</td>
<td>2.00E+10</td>
<td>2.00E+10</td>
<td>9.33E+10</td>
<td>8.78E+10</td>
</tr>
<tr>
<td>Co-60</td>
<td>BS</td>
<td>7.06E+07</td>
<td>8.01E+07</td>
<td>1.26E+08</td>
<td>3.46E+08</td>
</tr>
</tbody>
</table>

(b) Annual Limit on Intake (ALI):

Nasal swabs can be used for an initial magnitude assessment provided they are taken within the first hour of the exposure. For a first estimation of the magnitude of an intake it can be assumed that 10% of the intake will be found on the nasal swabs. Care must be taken to consider mouth breathing and/or cross contamination.

(c) Clinical Decision Guide (CDG):

The CDG is described in the National Council on Radiation Protection and Measurements (NCRP) Report 163 which uses potential medical ramifications as a decision point [2]. The CDG is a web-based calculator and expect the results to be correct. Inaccurate information will cause even the best system to provide incorrect results. One must continually evaluate the information for changes or inconsistencies that may impact the initial dose estimate.

4. Effective Communication

Integration requires involvement of all concerned relevant parties. Medical/hospital staff must relay their needs to the health physicist in a clear and concise manner, using easily understood terminology. Health physicists must explain dose assessment and risk to the patient and physician in an easily understood manner. Physicians and health physicists should avoid use of technical jargon, abbreviations and extraneous information when communicating with the patient and with each other. Together, they form a team that facilitates transmission of accurate and timely information to the patient, ancillary staff, public health personnel and public service leadership [7].

5. Conclusions

Optimal dose assessment, risk communication and medical care requires:
- Correct use of DRLs, ALIs and CDGs.
- Adjustment of time/distance activity in most (if not all) cases.
- Effective communication among health physicists and physicians who form an essential response unit.

References


3. External Dose Estimates

To assess external doses, one must know the radioisotope involved, the source activity; the distance from the source and the time/duration of the exposure [4]. It is usually difficult to pinpoint a dose by this method since victims are usually unaware they are being exposed. Tables can be used to calculate the dose to the victim, based on time/distance adjustments:

Table 2. Selected Radiation Dose Rate vs. Activity Information

<table>
<thead>
<tr>
<th>Radionuclide/Half-Life</th>
<th>Exposure Rate Constant*</th>
<th>f-factor*</th>
<th>Surface** (mSv/min-Gy)</th>
<th>Dose Rate at 1 cm Tissue Depth*** (mSv/min-Gy)</th>
<th>Dose Rate at 3 cm Tissue Depth*** (mSv/min-Gy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Co-60/5.26y</td>
<td>3.48</td>
<td>0.965</td>
<td>164.6</td>
<td>30.8</td>
<td>4.3</td>
</tr>
<tr>
<td>Ir-192/74d</td>
<td>1.24</td>
<td>0.964</td>
<td>48.7</td>
<td>11.6</td>
<td>1.5</td>
</tr>
</tbody>
</table>

* Exponent Rate Constants and Lead Shielding Values for Over 1,100 Radionuclides (Smith, Stabin – Health Physics – 102,3: 2012) – converted from conventional US units listed in the reference
** Primarily due to electron buildup in the capsule wall; from Vedevall, et al, DRL 13 (abstract 239406)
*** From NCRP Report No. 40 (1972), Appendix B, Table 2

Top: High dose rate (HDR) brachytherapy source, typically approximately 185-370 GBq Ir-192. Bottom: Industrial radiography source, Ir-192, activities can be in excess of 4 TBq.

Since other tools that can be used to assess radiation dose the health physicist must be aware of what is available, how to use the tools, and what the pitfalls are. One should not insert values into a formula or web-based calculator and expect the results to be correct. Inaccurate information will cause even the best system to provide incorrect results. One must continually evaluate the information for changes or inconsistencies that may impact the initial dose estimate.