Blocking agents prevent the entrance of radioactive materials. The best-recognized effective blocking agent is potassium iodide (KI), which blocks the uptake of radioactive iodine (^{131}I) by the thyroid. KI is most effective if taken within the first hour after exposure and is still effective 6 h after exposure. Its effectiveness subsequently declines until 24 h after exposure; however, it is recommended that KI be taken up to 48 h after exposure. The KI dose is based on age, predicted thyroid exposure, and pregnancy and lactation status. Adults between the ages of 18 and 40 should receive 130 mg/d for 7–14 days if exposed to ≥10 cGy of radioactive iodine. Other thyroid-blocking agents include propylthiouracil (100 mg tid for 8 days) and methimazole (10 mg tid for 2 days followed by 5 mg tid for 6 days). These agents are somewhat less effective than KI.

Diluting agents decrease the absorption of the radionuclide; for example, water may be used as a diluting agent in the treatment for tritium (^{3}H) contamination. The recommended amount is 3–4 L/d for at least 3 weeks.

Mobilizing agents are most effective when given immediately; however, they may be effective for up to 2 weeks after exposure. These agents include antithyroid drugs, parathyroid extract, glucocorticoids, ammonium chloride, diuretics, expectorants, and inhalants. All of the latter agents should induce the release of radionuclides from tissues.

Chelating agents can bind many radioactive materials, after which the complexes are excreted from the body. In this regard, diethylenetriaminepentaacetic acid (DTPA)—as either Ca-DTPA or Zn-DTPA—is superior to ethylenediaminetetraacetic acid (EDTA); DTPA has been approved by the FDA to treat internal contamination with plutonium, americium, and curium, but it also chelates berkelium, californium, and any other material with an atomic number >92. Ca-DTPA is more effective than Zn-DTPA during the first 24 h after internal contamination, and the two drugs are equally effective after the initial 24 h. If both drugs are available, Ca-DTPA should be given as the first dose. If additional treatment is needed, treatment should be switched to Zn-DTPA. The dose is 1 g of Ca-DTPA or Zn-DTPA, dissolved in 250 mL of normal saline or 5% glucose and given intravenously over 1 h daily. The duration of chelation treatment depends on the amount of internal contamination and the individual response to treatment. DTPA also can be administrated by nebulized inhalation; 1 g is given in a 1:1 dilution with water or saline over 15–20 min. Nebulized Zn-DTPA is recommended if inhalation was the only route of internal contamination. The IV route is recommended and should be used if the route of internal contamination is not known or if multiple routes of internal contamination are likely. DTPA penta-ethyl ester is a prodrug that has a favorable oral-absorption profile and whose therapeutic effects have been demonstrated in initial efficacy studies. Because it can be given orally, this prodrug may ultimately prove more useful in the setting of mass casualties than IV or nebulized forms of the drug. Treating uranium contamination with DTPA is contraindicated due to synergistic damage to the kidneys.

Lung lavage can reduce radiation-induced pneumonitis and is indicated only when a large amount of radionuclide enters the lungs and has the potential to cause acute radiation injury. The procedure requires anesthesia.

MEDICAL ASSAY OF RADIATION IN THE EXPOSED PATIENT

One of the major difficulties in treating victims exposed to radiation is determination of the amount of exposure. Immediately after a terrorist event, when victims are being triaged, information regarding source, dose, and exposure time is unlikely to be available. Clinical assessment of the patient is the best approach and includes history, physical examination, and observation for onset of the ARS prodrome. An early prodrome indicates high-level exposure to radiation. Victims who arrive at the hospital reporting severe weakness, nausea, vomiting, diarrhea, or seizures probably will not survive despite supportive measures. A very limited number of tests can be performed to estimate radiation exposure and contamination. The Biodosimetry Assessment Tool (BAT) facilitates treatment decisions during radiation exposure incidents. Developed by the U.S. Armed Forces Radiobiology Research Institute (AFRRI), the BAT provides a method of estimating radiation exposure on the basis of a single lymphocyte count, the lymphocyte depletion rate, and the time from exposure to onset of emesis. The BAT algorithms are based on large datasets from human radiation exposure and are available at *http://www.usuhs.mil/afrri/outreach/request.htm*. The patient should be observed for clinical symptoms, and the severity and time of onset of nausea, vomiting, headache, anorexia, fever, hypotension, tachycardia, weakness, cognitive changes, skin desquamation, diarrhea, and bloody stools should be recorded. The AFRRI Biodosimetry Worksheet (*http://www.usuhs.mil/afrri/outreach/pdf/afrriform331.pdf*) is a useful resource for detailed recording. Baseline tests should include a complete blood count with differential and platelet count, renal evaluation, and determination of electrolytes, serum amylase, and serum C-reactive protein. Urine and stool samples should be obtained if internal contamination is suspected. Nasal swabs taken from each nostril within the first 1–2 h after the exposure may be useful for determination of radionuclide inhalation. After exhalation, each swab is labeled, sealed in a plastic bag, and sent for analysis to appropriate laboratories. Patients exposed to 0.7–4 Gy develop pancytopenia from as early as 10 days to as late as 8 weeks after exposure. Lymphocytes show the most rapid decline, whereas counts of other leukocytes and platelets decline less rapidly. Erythrocytes are the least vulnerable blood elements.

Absolute lymphocyte counts should be repeated every 4–6 h for 5–6 days; they are the most valuable early indicator because they constitute a sensitive marker for radiation damage and correlate with both the exposure and the prognosis. A 50% drop in absolute lymphocyte count within the first 24 h indicates a significant injury. HLA typing is necessary whenever irreversible bone marrow damage is suspected. Lymphocyte chromosomal analysis can detect exposure to as little as 0.03–0.06 Gy, and 15 mL of blood for this purpose should be drawn as early as possible in a heparinized collection tube and kept cool. Radiation-induced chromosomal aberrations visible in peripheral-blood lymphocytes include dicentric chromosomes and ring forms that last for a few weeks. Calibration of a dose-response curve makes it possible to assess the radiation dose on the basis of the presence of these aberrations. Dicentric quantification requires multiple days to perform and is available only in select centers.

Another method for estimating exposure is the in vitro cytokinesis–block micronucleus assay. Micronuclei can be the result of small acentric chromosome fragments that arise during exposure to radiation. The technique to score the micronuclei in peripheral-blood lymphocytes has been standardized in the last few years. It can be a useful tool in small-scale exposures but is not feasible in a mass casualty setting.

FOLLOW-UP

It is desirable to continue follow-up over the long termin some circumstances. In general, only persons who are exposed to <8–10 Gy of whole-body irradiation have a chance to survive in the long term, and they are at risk of developing cataracts, sterility, and cancers as well as lung, kidney, and bone marrow problems. In light of their age, their gender, and the amount and type of exposure, they should be followed for many years. A major public health issue is the risk of secondary malignancy in individuals and populations that have been exposed to low doses of radiation. Leukemia and breast, brain, thyroid, and lung cancer develop most commonly, but the exposed population is at increased risk for many other cancers as well. Appropriate follow-up protocols should be based on the type of exposure and the exposed population. In cases of internal contamination, long-term follow-up should be focused on the organ at risk. Substantial psychosocial support will likely be needed for a community in the years after an attack including radiologic agents.