used PET tracer in nuclear medicine and has an effective radiation dose of 6–8 mSv. For comparison, the effective dose from background radiation when living in Europe is in the range of 2–7 mSv/year. Radiation dosage for a chest X-ray is ca. 0.02 mSv and for a CT scan of the chest 6.5–8 mSv.

8.5 SELECTION OF RADIONUCLIDES: SHORT- OR LONG-LIVED ISOTOPES?

A number of parameters need to be considered before a suitable nuclide can be selected for the task at hand, for example:

1. The half-life ($T_{1/2}$) of the nuclide in relation to the kinetics of ligands interaction with the target (How long does it take for the ligand to locate and bind to the target; minutes or hours?)
2. The β^+-range: The distance from the originally decayed radionuclide to the annihilation point, which depends on the energy of the emitted positron, which in turn depends on the nature of the parent radionuclide. The β^+-range influences the spatial resolution of the final PET images; the lower the range the higher the resolution.
3. The β^+-branching ratio, which will influence the radiation burden of the patient: a lower branching ratio will lead to a higher radiation burden. It can be seen as the percentage of the emitted radiation that adds to the final image.
4. The target localization (Will the PET ligand have to pass over cell membranes or perhaps even the blood–brain barrier? This can influence the choice between nonmetal and metal-based ligands).

Table 8.1 summarizes some important physical properties of commonly applied positron-emitting nuclides.

PET nuclides can be divided into short-lived (minutes to 2 hours) and long-lived (several hours to days), as well as into nonmetal and metal nuclides. In the following, the advantages and disadvantages of these nuclides will be discussed.

TABLE 8.1
Selected Radionuclides for PET Imaging

Nuclide	Half-Life ($T_{1/2}$)	Branching Ratio (%)		Mean β^+-Range in H_2O (mm)	Specific Activity (GBq/μmol)
^{11}C	20.4 minutes	β^+	99.8	1.1	20–100
^{18}F	110 minutes	β^+	96.9	0.6	200–1000
^{68}Ga	68 minutes	β^+	89.1	2.9	Carrier-free[a]
^{64}Cu	12.7 hours	β^+	17.8	0.6	Carrier-free[a]
^{89}Zr	78.4 hours	β^+	22.7	1.2	Carrier-free[a]

Note: $T_{1/2}$ is the amount of time required for a radioactive quantity to decay to half of its original value; the branching ratio is the fraction of particles which decay by an individual decay mode with respect to the total number of particles which decay; the β^+-range specifies the distance until the β^+-particle annihilates with an electron and is thus one factor that controls the spatial resolution of a PET tracer.

[a] Carrier-free indicates that the nuclide is essentially free from stable isotopes of the element in question (carrier). In reality, it is almost impossible to achieve carrier-free samples, but for radiometals the level is assumed to be very low.