HADRÓN THERAPY
Atom

Nucleus of Carbon = 6 protons + 6 neutron

Proton or Neutron

Hadrons consist of quarks

“u” or “d” quark

electron
Hadron therapy is a kind of radiation therapy by using some particles. (Proton, Neutron, pion and some ions i.e. alpha, Ne, C...)

Photons (massless particles) are used in radio therapy.

The main difference of hadron therapy is using heavy particles on tumor cells.

For example: mass of proton is 1 Gev
mass of electron is 0.511 Mev
The purpose of radiotherapy is to apply harmful effects of radiation against tumor cells while doing as little damage as possible to healthy normal cells. This technology is used for treatment of cancer.

Energy and wavelength are inversely proportional to each other. So, Gamma and X-rays (having the smallest wavelengths in spectrum) are used to destroy tumor cells.

Generally, the dose of these rays is 2-2.5 Gy (1 Gray = 1 J/kg) against typical tumor. While the ray is applying on tumor cells, maximal 1-1.2 Gy has to reach other areas. The average length of these treatments is 30 times in 6 weeks. Thus, the patient is exposed to 60-75 Gy during the treatment.
HADRON THERAPY

- Proton, neutron, pion and ions (helium, carbon, oxygen, etc.) are used at Hadron Therapy. The most important point of these particles is not to lose their energies easily while they are passing through any matter. Moreover, they can be able to make interaction with matter after fixed distance. So this makes Hadron therapy more effective than radiotherapy.
In Proton therapy, the sending radiation can be focused on tumor cells (pinpoint bombing). The range of protons is high, so they can reach deeply areas where are impossible to reach by surgical operations. While proton approaches last of its range, the dose of its radiation increases abruptly (Bragg effect). Thus this treatment does not damage to unwanted tissues.

235 MeV Proton Bragg Curve

- Suitable for 1.5 cm diameter tumor.
- Skin dose ~30% of maximum dose.
Spread-Out Bragg Peak
235 MeV Spread Out Bragg Peak

- Suitable for 9 cm diameter tumor.
- Skin dose 68% of maximum dose
Neutron Therapy Beam [ p(66) Be(49) ]

Before Neutron Therapy

After 7 treatments 12.25 Gy of neutrons
Inoperable Soft-tissue Sarcoma

Before

End of treatment

Two-month follow-up
Inoperable neck tumor before neutron therapy

Before

After 2 years
COMPARING

Healthy tissue
Tumor area
Effect of proton
Sensitive organ

Proton

X-ray

Relative dose [%]

0 20 40 60 80 100 120

0 2 4 6 8 10 12 14

depth [cm]
X-rays, 7 portals

Protons, 3 portals
The PSI PROSCAN Facility (a) sc accelerator, (c and d) gantries, (e) Eye treatment room
CONCLUSIONS

1. Hadron cancer therapy facilities are being built at a rapid rate. The efficacy of hadron therapy is accepted, but these facilities are expensive. (“The best and the worst of medicine.”)

2. It is unclear if carbon is better than protons, but the Japanese are sold on it. (The RBE is perhaps the most important aspect.) The Americans are going only for protons.

3. Spot scanning may be medically advantageous, and it requires a cyclotron or fast cycling synchrotron, and seems to be the way the world is going.

4. The accelerator is only about 25% of the cost of the facility.

5. Gantries are about 25% of the cost of the facility and they may not be needed.

6. All present facilities are synchrotrons or spiral ridge cyclotrons, but a linac is under construction in Italy.