Problems with irradiators


In Japan, where all cell concentrates are irradiated because of an unusually high risk of transfusion-associated graft-versus-host disease (GVHD) due to the high percentage of HLA homozygous subjects in the population, there have been problems with the breakdown of IBL gamma irradiators. When an irradiator breaks down, it is often found to be difficult for the agencies, or even the manufacturers, to repair it. Furthermore, it seems to be difficult in Japan to obtain new irradiators. Finally, the US Nuclear Regulatory Commission Task force recommends the phase-out of Cs-137 irradiators in 2 years to prevent terrorists using the isotopes, though the bill is not likely to be submitted.

Although in no other country all cell concentrates are irradiated, there are indications for irradiation in all of them. It seems therefore of interest to investigate whether there are similar problems outside Japan. To obtain information, the following questions were sent to the relevant authorities:

**Question 1**
Which irradiators are used in your centre/country?

**Question 2**
If an irradiator breaks down, is it easy (possible) to have it repaired? If there are problems, what are they?

**Question 3**
Do you encounter difficulties in obtaining a new irradiator?

**Question 4**
Which manufacturers, to your knowledge, sell irradiators or are planning to develop one, either a gamma ray or an X-ray irradiator?

**Question 5**
Will the advice of the US Nuclear Regulator Commission Task Force be followed in your centre/country?

We received eight contributions to this Forum. It appears that a total of eight different irradiators are used, both gamma and X-ray irradiators. Of these, the Gammacell Elan 3000 (Best Theratronics, ON, Canada) is the most frequently applied (see table).

### Table Gamma and X-ray irradiators used

<table>
<thead>
<tr>
<th>Name</th>
<th>Frequency</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biobeam</td>
<td>6</td>
<td>Bebig, Germany</td>
</tr>
<tr>
<td>Gammacell Elan 3000</td>
<td>7</td>
<td>Best Theratronics, Ontario, Canada</td>
</tr>
<tr>
<td>Gammacell 2000</td>
<td>2</td>
<td>Best Theratronics, Ontario, Canada</td>
</tr>
<tr>
<td>Gammacell 1000 Elite</td>
<td>4</td>
<td>Best Theratronics, Ontario, Canada</td>
</tr>
<tr>
<td>Gammacell 4</td>
<td>1</td>
<td>Best Theratronics, Ontario, Canada</td>
</tr>
<tr>
<td>IBL-437C units</td>
<td>3</td>
<td>CIS Biointernational, France</td>
</tr>
<tr>
<td>OB 29/4-8A</td>
<td>1</td>
<td>STS Buckler, Germany</td>
</tr>
<tr>
<td>MBR-1520-TW</td>
<td>1</td>
<td>Hitachi Med. Corp, Japan</td>
</tr>
<tr>
<td>Raycell</td>
<td>9</td>
<td>Best Theratronics, Canada</td>
</tr>
</tbody>
</table>

Problems rarely encountered with irradiators are electronic problems, problems with the turntable, with radioactive sources or the protection envelop. Preventive maintenance according to the manufacturer’s schedule was found to assure good performance of all gammacell irradiators (see the contributions from Poland and Spain). In some countries repair of broken down irradiators is no problem, e.g. when one of the X-ray tubes broke down in Sweden, it could easily be replaced. However, at the Yale University Hospital, it was found that repairs often take 14 days, which necessitated seeking help from other hospitals in the region. As mentioned, in Japan, it is difficult to find technical support.

In general, there do not seem to be great problems in obtaining a new irradiator, apart from the large sum of money involved and, in the USA, the regulatory issues involved when a new irradiator is needed. However, in Japan it is impossible at present to obtain a new irradiator.

Apart from the manufacturers mentioned in the table, the following are also known to sell irradiators:

- Gamma-Service Medical GmbH
- Biobeam, Bebig, Germany
- Cegelec NDT, France
- Gilardoni, Italy

Furthermore, Elekta, Varian and Siemens are selling linear accelerators that produce photon beams.

The advice of the US Nuclear Regulator Commission Task force to phase-out of Cs-137 irradiators in 2 years to prevent terrorists from using isotopes is at present not
followed in any country, although in France the national strategy agrees with this advice.

In conclusion, the problems encountered in Japan, where irradiating cell concentrates is more important than anywhere else, to have broken down irradiators repaired, or to buy a new one, do not exist in the other countries/centres from which a contribution to this Forum has been received, although there are some practical problems to overcome during the time it takes for the repair. Phasing-out of Cs-137 irradiators is, except in France, not considered at present.

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A. Chabanel, G. Santailier, T. Guérin, D. Socquet & B. David

1. The blood component irradiators used in France are of two types:
   • Gamma irradiators: IBL (CIS Bio International, France) and Biobeam (Bebig, Germany)
   • X-ray irradiators: Raycell (Best Theratronics, Canada)

2. Gamma Cs-137 irradiators are quite robust and have a high mean time between failures (MTBF). Minor problems not related to the radioactive sources are usually repaired within 48–72 h. When radioactive sources, or the protection envelop, are concerned, which is a rare occurrence, blood components are irradiated in the nearest blood center.

   Our experience with X-ray irradiators is recent. Since December 2005, EFS bought 10 Raycell irradiators. We had four major problems with Raycell irradiators which have necessitated three generator replacements (under guarantee). Also, we observed phenomena of arcing in X-ray tubes during irradiation which have caused the cycle to stop and have resulted in the discontinuation of the irradiation process for the implicated blood components.

3. Purchase of new irradiators is made through national invitation to tender with or without competition. Between April 2008 and October 2008, we had some delivery problems for the Raycell irradiators, probably linked to the selling of this Nordion activity to Best Theratronics.

4. Manufacturers selling X-ray irradiators are: Best Theratronics (Canada), Cegelec (France) and Hitachi (Japan).

5. As we are under the strict regulation and control of the French Nuclear Security Authority (ASN), we do not have to follow the US Nuclear Regulator Commission Task Force recommendation. However, since few years, EFS is engaged in the progressive replacement of gamma Cs-137 irradiators by X-ray irradiators for security and administrative reasons. As a result, it appears that the French strategy on that matter agrees with the US position.

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J. L. Labrune

Cegelec NDT is a part of Cegelec Group acting over the world.

For more than 30 years Cegelec NDT is involved in the non-destructing testing field and now in the medical field by providing almost all kind of equipment, consumables and services, having distribution agreement with major world producers [see our website: http://www.ndt. cegelec.com].

Cegelec NDT has been gathering over decades a huge experience in providing solutions mainly for not only automotive, aeronautics, trains, space, electronics industries and but also for military, research, museums and now medical.

Cegelec NDT is one of the major NDT actors in France especially in X-rays field where our strong experience acquired over the success of numerous references is well known.

Based on this experience, Cegelec NDT designed and produces a new X-rays irradiator named BloodXrad especially dedicated for blood bag irradiation.

Our department Products and Systems is located to the south of Paris with an agency in Lyon and employees 65 people.

The availability of our laboratories for feasibility with X-rays but also ultrasonic and eddy currents allows Cegelec NDT to offer the optimal and most economical solutions, to answer the customer’s needs.
Cegelec NDT assists its customers by providing a full range of services aimed at supporting equipment:
After-sales service and maintenance contracts
Training
Technical consultancy, radiation protection advices
Logistic

Features of BloodXrad
- X-ray tube voltage: 160 kV
- High dose rate output: up to 7 Gy per minute (35 Gy in 5 min)
- Rugged and reliable design
- High dose stability
- High dose reproducibility
- Intelligent automatic X-ray tube warm-up
- Bar code reader for blood bag identification
- Large size touch screen for the human interface machine
- Three access levels (user, administrator, maintenance) by passwords
- Clear text messages and menus
- Programmed mode and manual mode (depending on the authorized level of operator)
- History of data and parameters recorded
- Full on-site maintainability (including the high voltage generator)
- Local diagnostics
- Safety and protective devices
- Cooling system (option)
- CE Medical compliance: certificate no 12247

Answer to question no 4

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C. K. Lin & W. C. Tsoi

Question 1
The Hong Kong Red Cross Blood Transfusion Service is currently operating one set of Caesium-137 source blood irradiator (Gammercell® 3000 Elan; Best Theratronics, Canada) to provide territory-wide supply of irradiated blood products.

Question 2
We do not encounter any major difficulties in requesting the local vendor to fix breakdown of our blood irradiator, which is still under warranty. Previously when we operated an older model, the major problem was in finding spare parts to replace the defective ones, mostly mechanical parts, such as the turntable.

Question 3
The major difficulty is in seeking the necessary funding, otherwise, there are no particular difficulties which deter us from procuring a blood irradiator to meet service needs.

Question 4
Other than those common names appear in the commercial market supplying Cs-137 sourced irradiators (such as Gammercell of Best Theratronics, Canada; OB29/4-BA of STS-Buchler, Germany) and X-ray based equipment (such as Raycell CE of Best Theratronics, Canada; MBR-1520A-3 of Hitachi Medical, Japan), we are not aware of other suppliers of planning to develop similar products.

Question 5
The advice of the US Nuclear Regulator Commission Task Force has not been put up as discussion agenda by the local regulatory authority.

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K. Tadokoro

Question 1
In Japan, we had 64 cases of transfusion-associated graft versus host disease (TA-GVHD) between 1992 and 1999, which were confirmed by the presence of chymerism using micro-satellite analysis. These cases are detected by a nationwide haemovigilance system established in 1992. High frequency of HLA homozygosity among the Japanese population seems to be the cause of such a high incidence of TA-GVHD. In fact, the majority of examined cases occurred in HLA one way mismatch transfusion to apparently immuno-competent patients. To prevent this fatal side-effect, the Japanese Red Cross (JRC) Blood Service, obtained an approval for irradiated blood and components and started to supply them in 1999. In Japan, almost all the cellular components are irradiated before transfusion either in JRC blood centers or medical institutions. We have seen no case of TA-GVHD since 2000. In addition, we have observed no increase in the number of reported transfusion-associated hyperpotassemia which is known to be a risk of transfusion of irradiated blood components.
For irradiation, we use gamma irradiators such as IBL (CIS International, France), OB29/4 (STS Buchler, Germany), Gammacell 40 (MDS Nordion, Canada) and bi-directional X-ray irradiator MBR-1520-TW (Hitachi Medical Corp, Japan). Gamma irradiators constitute 15% of the total number of irradiators and are used in big scale blood centers, because they can irradiate blood in a shorter time with low running costs.

**Question 2**
In Japan, we had three cases of breakdown of the CIS International IBL gamma irradiator in 2008, after 8 years of full running. As French CIS International stopped to sell the irradiator, we have no Japanese agency or branch of the gamma irradiator manufacturer which can keep and repair gamma irradiators directly. Only one company gave us technical support to repair the mechanical problems successfully. But, it took several months to solve the problem. As for X-ray irradiators we have little problem of break-down, although X-ray tubes have to be renewed every 1200 h of irradiation or every 1 year of use.

**Question 3**
French CIS international stopped to sell the new irradiators 7 years ago. We have no agency which deals with new gamma irradiators in Japan. Hitachi Medical Corp. is not manufacturing or selling new X-ray irradiators at present. Therefore, it is difficult to obtain new irradiators when they break down.

**Question 4**
We have no manufacturer or agency which sells new gamma irradiators in Japan. Hitachi Medical Corp. is not selling new X-ray irradiators at present.

**Question 5**
In Japan, there is no political movement for phasing-out of gamma irradiators to prevent terrorism using isotopes. But, it appears that regulations for the usage, transport, storage and disposal of gamma irradiators are getting more stringent globally. Gamma irradiators are especially suitable for big blood centers and cost less in their maintenance in comparison to X-ray irradiators, but might cost more when the disposal cost is included. We are now co-developing next generation X-ray irradiators which comply more with current GMP.

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1. There are three types of blood irradiators used for irradiation of blood components in Poland: Gammacell 1000 Elite and Gammacell 3000 Elan manufactured by Best Theratronics, Canada, formerly part of MDS Nordion, Canada as well as IBL-437C units, manufactured by CIS (France). The whole basis for blood irradiation consists of 16 Gammacell units and four IBL units.

2. The authorized service for Gammacell irradiators in Poland is maintained by the Best Theratronics team, Canada which continues the good practice of its predecessor, MDS Nordion. The maintenance, service and dose validation procedures are performed on the service contract basis. Preventive maintenance provided according to manufacturer’s schedule assures good performance of all Gammacell irradiators (see Appendix below). Some of them are more than 10 years old; the oldest was installed 16 years ago. As yet, none of the Gammacell irradiators have been out of service due to break down.

3. New irradiators can be obtained from Best Theratronics within 3 months of sending in the order. The only problem for Blood Bank facilities in our country is to obtain enough money for the purchase of a new unit.

4. Best Theratronics sells gamma ray as well as X-ray irradiators suitable for blood irradiation. Our knowledge about the offer of other manufacturers has not been updated recently.

5. The Polish regulations following our Act of Parliament Atomic Law contain the following clauses in Article 43:
3. Head of the organizational entity engaged in activities involving radioactive sources shall be responsible for securing them against damage, theft or unauthorized interception.
4. Council of Ministers may establish – by regulation – the methods of protecting high activity sources against damage, theft or unauthorized interception, taking into account the necessity to prevent the occurrence of a radiation emergency related to such source.

In all our blood irradiation facilities appropriate measures have been taken to fulfill these requirements. Some protective installations were supported by the US Department of Energy to establish sufficient level of protection against terrorists.

**Appendix**

MDS Nordion (Canada) as manufacturer of Gammacell 3000 Elan irradiator, recommends the following quality assurance measures to be used.
1. Every 3 months the dose rate of irradiation outside the equipment must be checked.

2. Once a year:
   - Make sure there is no radiation leakage
   - Check electric connections and battery parameters
   - Check the motor drive of the container and screen
   - Check state and performance of various parts or sub-assemblies for premature material wear

3. Every 3 years – Validation of dose mapping.

4. Every 5 years – Change of battery.

5. After 8 years of use – Change of RAM (SBC) battery.

6. All maintenance service activities should be performed by authorized manufacturer representative agent – RTA Sp.z o.o.

7. RTA Sp.z o.o. – as authorized representative of the manufacturer – may introduce changes into the service schedule to include any of the manufacturer’s recommendations.

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M. Lozano
1. In our Hospital, as in most of the Spain’s Centres, the type of irradiator most often used are Cs-137 irradiators.

2. So far we have not had any problems with the maintenance of our Gamma Cell 1000 irradiator (MDS Nordion). Every year a preventive maintenance is performed by the manufacturer and in case of breakdown a corrective maintenance is undertaken.

3. In Spain, we do not experience any difficulties in obtaining new irradiators, either X-ray or Cs-137.

4. I am aware of a Spanish distributor or MDS Nordion equipment.

5. I do not think that the advice of the US Nuclear Regulator Commission Task Force will be followed in Spain. The difficulties for dismantling the CS-137 irradiators and the cost of the replacement will probably preclude its approval.
corrected by installation of new batteries and other electronic problems which have been repaired.

In Stockholm, they have encountered a mechanical problem with the turntable on Gammacell Elan 3000, which was replaced.

Problems with Raycell: one of the X-ray tubes broke down and was replaced.

**Question 3**

No. There is no major problem to obtain a new irradiator.

When obtaining a new irradiator, it must be reported to, and approved by the Swedish Radiation Safety Authority. There are also special regulations for this kind of equipment regarding transportation etc and special requirements must be fulfilled by the facility where the equipment is located, but otherwise no difficulties.

A linear accelerator is expensive but contains of course no isotopes.

**Question 4**

1. BestTheratronics (former MDS Nordion) through the Swedish agent Nuklex, Inc.
2. Gamma-Service Medical GmbH
3. Elekta, Varian and Siemens are manufacturers selling linear accelerators that are producing photon beams.

**Question 5**

No, we will follow the European regulation 96/29/EURATOM ‘Basic Safety Standards, BBS’ and 97/43/EURATOM ‘Patient Safety’. Swedish Law and SSM (Swedish Radiation Safety Authority) regulations.

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**Question 1**

At Yale New Haven Hospital, we use the Nordion 3000 Elan Gamma Irradiator. It was manufactured by MDS, Nordion, ON, Canada, but is now marketed by Best Theratronics from Ontario, Canada. We use this device exclusively.

**Question 2**

Emergency repair of the irradiator is a major problem. The manufacturer must be notified and the service person must then schedule a visit to our site. There can be up to a weeks delay in the repair being effected. The primary problem is scheduling a repair call and assuring that the part(s) is(are) available. In the interim, the hospital must find a solution to the inability to irradiate cellular products in-house. In Connecticut, the American Red Cross can provide irradiated products as can the West Haven Connecticut, VA Hospital. The Rhode Island Blood Center can also irradiate blood products. The ability of these sources to irradiate for Yale, however, is problematic as the volume of irradiated products we need can be substantial due to a large oncology program. Coordinating receipt of irradiated products can be very challenging and we request that the manufacturer send a repairman out on an emergency basis. The cost of the repair is also an unbudgeted expense and obtaining Hospital funding for the repair takes time and paperwork. Purchasing a back-up in-house device would be too expensive.

**Question 3**

Obtaining a new irradiator whether it be a gamma irradiator or an X-ray device is a major problem due to several factors. These include, cost of the new item, as the machine is a capital expense. Thus, major justification must be provided and paperwork must be filled out. Obtaining funding is a laborious process which requires that our section’s priorities compete with other hospital priorities for a finite pool of dollars. The regulatory filings are also extensive if a gamma irradiator is sought. If an X-ray device is chosen, the regulatory issues are much less of a problem.

**Question 4**

BEST Theratronics has assumed control of Nordion’s irradiator products. They have both gamma and X-ray models. I am unaware of the status of other manufacturers’ plans.

**Question 5**

The US NRC, for now, has decided to pull back a requirement that gamma irradiators be phased out. The NRC’s ‘advice’ is very binding and is followed to the letter of the law in the US. Failure to do so can result in loss of the NRC license and have probable legal and possible criminal repercussions for failure to comply. Many Hospitals, such as Yale, are keeping their gamma irradiators for now and others are going to purchase X-ray devices going forward. While the need for such an irradiation device (gamma or X-ray) is absolutely critical for oncology and other patient care, it is difficult to know how the field will be regulated in the future. A crystal ball would come in handy.