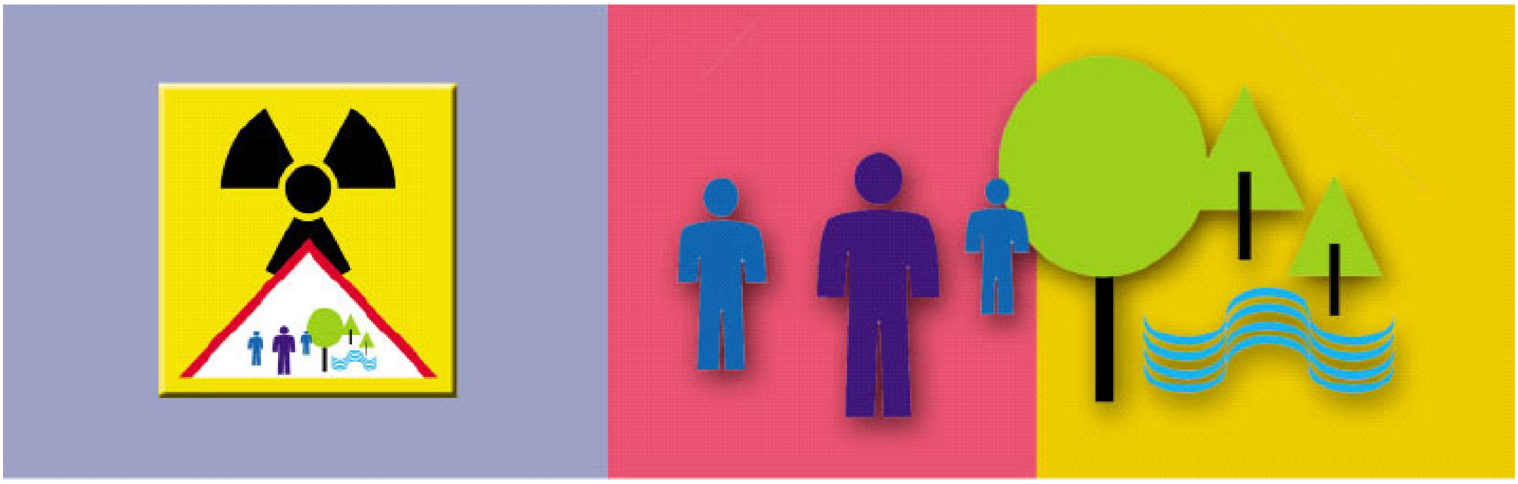
RADIATION PROTECTION



Medico-legal exposures, exposures with ionising radiation without medical indication

Proceedings of the International Symposium
Dublin, 4-6 September 2002

Issue N° 130

EUROPEAN
COMMISSION

EUROPEAN COMMISSION

Radiation Protection 130

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Directorate-General for Energy and Transport
Directorate H – Nuclear Safety and Safeguards
Unit H.4 – Radiation Protection

2003

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Luxembourg: Office for Official Publications of the European Communities, 2003

ISBN 92-894-6890-4

Printed in Belgium

PRINTED ON WHITE CHLORINE-FREE PAPER

Text completed on 30 October 2003

This publication is also available on the Internet via:
http://europa.eu.int/comm/energy/nuclear/radioprotection/index_en.htm

Contract ID: 2002/336772/02
EC Project co-ordinator: Mercedes SARRO VAQUERO

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Foreword

Council Directive 97/43/Euratom of 30 June 1997 regulates health protection of individuals against the dangers of ionising radiation in relation to medical exposure. This Directive repealed and replaced, as from 13 May 2000, Directive 84/466/Euratom, which constituted a first attempt at regulation of such exposures at a Community level.

Directive 97/43 takes into account the latest scientific developments, and has as its primary aim to minimise the health detriment resulting from medical exposures, which remain at present the major man-made source of exposure to ionising radiation. It therefore develops the provisions in the former Directive, giving more detailed rules on the application of the justification and optimisation principles and fixing stricter requirements for responsibilities, procedures, training and equipment, but also extending its scope to exposures which were not covered in the past.

The so-called "medico-legal exposures" are dealt with for the first time in Directive 97/43/Euratom, which defines them as those procedures performed for insurance or legal purposes without a medical indication. Furthermore, the Directive requires that special attention be paid to justification and optimisation of such practices, and that clear procedures and responsibilities be defined.

The term "medico legal exposures" covers a wide range of possible scenarios and exposures of very different nature, for which the only feature in common is the fact that the main reason for performing them does not directly relate to the health of the individual being exposed to ionising radiation.

The difficulties in the implementation of the provisions on medico-legal exposures in Directive 97/43 are evident: Member States need to give a clear definition of this kind of exposures, they have to identify those exposures that can in principle be justified and those that can never be justified. Only after this identification is it possible to give special rules and guidance on justification and optimisation of every single exposure, and define specific procedures according to every possible scenario.

In this case, more than ever, the effectiveness of the provisions of the Directive strongly depends on the awareness of all the individuals who can possibly be involved in medico-legal exposures. These individuals are not necessarily health professionals and, in some cases, lack radiation protection training.

With a view to raising awareness to the various situations in which an exposure to ionising radiation can be made for medico-legal grounds and with the aim of providing a forum for international discussion on these practices, the European Commission organised an international conference.

The "International Symposium on Medico-Legal Exposures", organised by the European Commission with the co-operation of the Radiological Protection Institute of Ireland, was held in Dublin, Ireland, on 4-6 September 2002.

It gathered a broad spectrum of professionals with responsibilities in the fields of Customs, Immigration, Internal Affairs, Industry, Justice, Forensic Medicine, Radiology, Occupational Health and Public Health. International Organisations were also represented.

The meeting gave the opportunity to professionals involved in the use of x-rays for medico-legal purposes and other interested parties to exchange their experiences and views about the ethical, legal, social and technical problems encountered with these practices.

A. Janssens
Acting Head of Unit

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Introduction

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In 1997, the Council Directive 97/43/Euratom on the health protection of individuals against the dangers of ionising radiation in relation to medical exposures (the Medical Exposure Directive (MED)) was issued. Medico-legal exposures were included in the list of medical exposures and defined as '*exposures performed for insurance or legal purposes without a medical indication'*. The Directive requires that special attention be given to justification and optimisation of these exposures. The Directive also states that a medical exposure that is not justifiable should not be allowed. Because of this, but also for ethical reasons, the justification of these exposures is very important.

Within the context of the Directive a medical exposure includes not only those exposures that are part of the normal diagnosis and treatment of patients but also exposures for occupational health surveillance, health screening programmes, research and medico legal procedures. This can lead to a degree of ambiguity when discussing medico-legal exposures and exposures which have a medical indication. Often, the latter are referred to simply as medical exposures – a term that is clearly imprecise within the context of the Directive.

Medico-legal exposures are difficult to define and it is not always easy to decide which exposures are 'real' medico-legal and which are not. Often certain exposures could also be interpreted as being occupational or medical. The definition mentioned above is not sufficient to solve this problem. The reason for this would seem to be that the range of exposures that could now be considered to medico-legal were simply not envisaged when the Directive was originally drafted. It may be that a more complete definition of medico-legal exposures is required.

Medico-legal exposures are indeed exposures without a (strict) medical indication, but they are not only performed for insurance or legal purposes. The term should also include other exposures where the aim is to expose people for reasons other than medical diagnosis or treatment, but not necessarily for insurance or legal reasons.

The term '*medical indication'* is also difficult to define precisely. Investigations, using x-rays etc, are considered to be medically indicated if there are clinical symptoms, which indicate that something should be investigated in order for a correct diagnosis to be made, or to start or follow up some clinical treatment.

Some examples will show the ambiguity:
An X-ray to diagnose a recently broken arm, with all of the usual symptoms, has undoubtedly a medical indication. In contrast, the use of x-rays in the age determination of asylum seekers would not seem to be medically indicated.

Chest x-rays of immigrants might be regarded as medically indicated when the person comes from a country with a high incidence of tuberculosis and positive identification of the disease results in the person being given treatment. However, if the positive finding merely results in refused entry to the country without offering medical care, it should be regarded as a medico-legal exposure.

There is a large range of reasons for non-medically indicated exposures and their justification has to be considered thoroughly.

Suppose a cargo is x-rayed to detect contraband, but illegal immigrants happen to be inside and are unintentionally exposed. There is clearly no medical indication, and the question can be asked, whether or not this is justifiable.

In some prisons, prisoners are X-rayed after the lunch break in order to detect knifes etc. This can happen either routinely or because there are suspicious circumstances. There is normally no medical indication for this exposure and there would be some debate about whether or not it is justifiable.

There is an increasing interest at airports in being able to check every visitor or passenger not only with a metal detector but also with X-rays or backscatter techniques to detect weapons. This means that millions of people could get a (very small) radiation dose. There is no medical indication for this type of exposure and if it is to be used, proper justification is essential.

In the case of cocaine smuggling, it could be argued that an X-ray can save the life of the person who swallowed the condoms. However using x-rays in this way will inevitably lead also to the exposure of individuals who have not in fact swallowed drugs.

The follow up of stress fractures in sportsmen is medically indicated and probably justifiable, but people will perhaps argue about scans to detect overloading due to intensive training. The use of x-rays to predict fitness for forthcoming sporting events is another application where there may be division about both justification and medical indication.

Another instance where x-rays are used is in growth prediction of young dancers. There seems to be no medical indication for this type of exposure and the justification is not clear-cut.

A totally different issue is the use of medical exposures to prove child abuse in court (not for diagnostic or treatment purposes). Exposures are performed, not only in cases of recent abuse, but also to detect past abuse. This can sometimes involve not only the abused child but also siblings who do not display any clinical symptoms.

The key issue in medico-legal exposures seems to be justification. Justification is the balancing of the advantages against the disadvantages, but both are difficult to quantify and are therefore often difficult to compare. The disadvantages could be the dose given, fear, public anxiety and the fact that some people are 'against' all of these kinds of things. The advantages could include safety, or the feeling of being safe, the avoidance of crime, reassurance, financial profit and a personal sense of well being.

This symposium is organised to draw attention to these exposures. It will specifically try to highlight all of the different aspects and try to give answers about the type of exposure (whether it is medico-legal, medical, occupational etc.) and about the justification. Some member states declare many of the exposures mentioned above as not justifiable and so they are forbidden. Others are sure that they are not and will not be performed in their countries. This symposium intends also to give some support to member states in the implementation of the provisions of the MED in relation to medico-legal exposures.

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Session I – Scope of the Meeting

Ionising Radiation and Radiobiological effects

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Because of the diversity of participants attending the symposium and the fact that some of them may not be familiar with ionising radiation or the radiobiological effects, a short explanation will be given below. A relatively simplistic approach will be adopted and this could give rise to small discrepancies with the real radiobiology and nuclear physics approaches.

Radiation

As the figure below shows, ionising radiation is one type of radiation at one end of the electromagnetic energy spectrum.

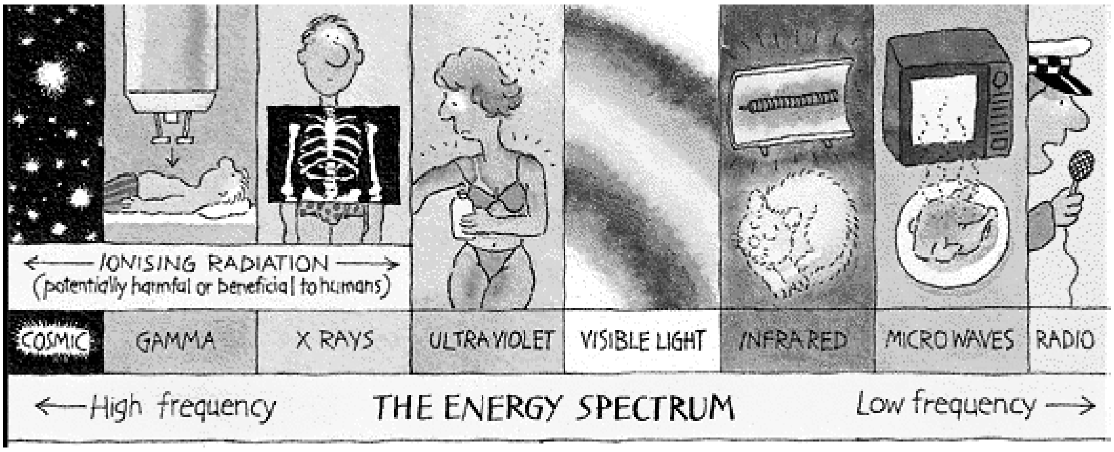


Figure 1 The energy spectrum, Eric J Hall, "Radiation and Life".

Ionising radiation has been present from the beginning of earth. All materials, humans, flora and fauna contain atoms, the basic building blocks of matter.

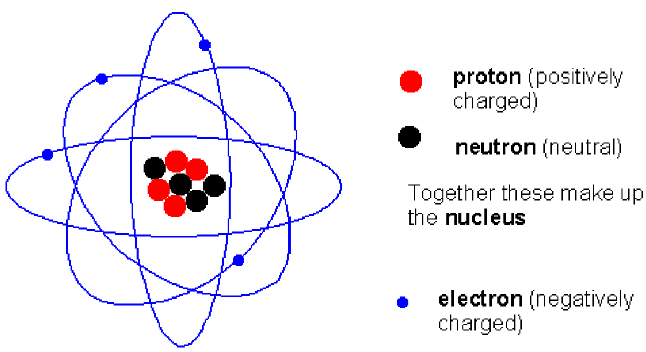


Figure 2 Schematic of an Atom

An atom contains protons, neutrons and electrons. A proton is positively charged and a neutron is neutral.
The neutrons and protons together make up the nucleus and the negatively charged electrons orbit the nucleus. Most atoms are stable and remain unchanged forever but certain atoms can disintegrate into a totally new atom. These atoms are called radionuclides. In the disintegration process, a radionuclide can emit radiation in the form of

particles or electromagnetic waves. This is called the decay of a radionuclide and the substance is said to be radioactive. Some radionuclides decay very quickly, for others it takes many years. The half-life is the time taken for half of the atoms of a radioactive substance to decay.

In radiation protection several types of radiation are considered. There is alpha radiation, beta radiation, neutrons (not common), gamma radiation and X-rays. Alpha and beta rays are particles whereas gamma radiation and x-rays are electromagnetic waves (energy packets). An alpha particle is a helium atom (2 protons and 2 neutrons) and a beta particle is a fast moving electron, which has been ejected from the nucleus of an atom. Gamma rays also originate in the atomic nucleus during the decay process, whereas x-rays are generated artificially. X-rays and gamma rays are virtually identical except for the way in which they are produced. Neutrons are neutral particles, which originate in the nucleus of an atom during the decay process.

Atomic electrons move around the nucleus in predefined paths or orbits. If a fast moving electron collides with the atom, electrons from inner orbits can be ejected. When this happens, electrons from outer orbits move to fill the gap and in doing so, release energy in the form of an x-ray.

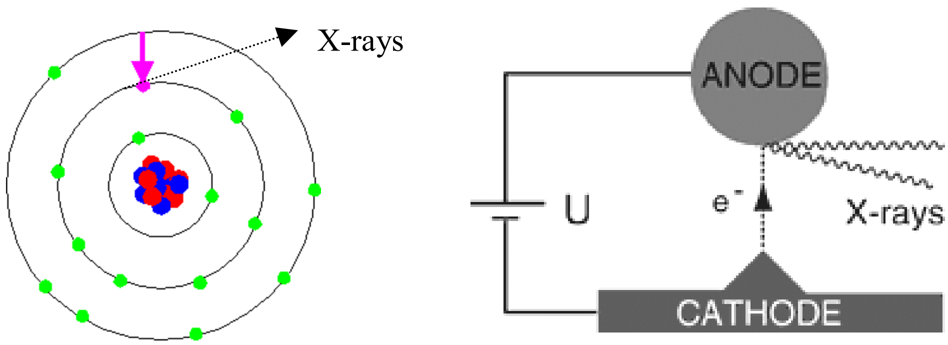


Figure 3 Generation of X-rays and the principle of an X-ray tube.

The different particles or waves have different penetrating powers, due to their size and energy. Alpha's can be stopped by a hand or even by a piece of paper. Most betas cannot pass through a thin slice of aluminium, while gammas and x-rays normally have to be stopped by lead. Neutrons need thick layers of concrete to be blocked.

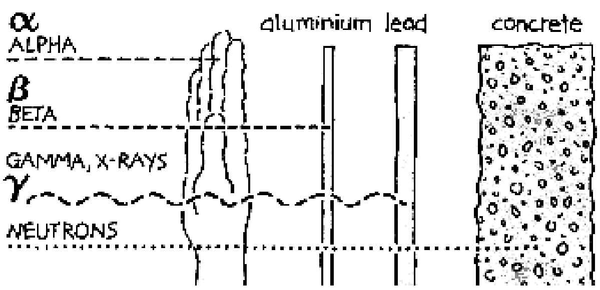
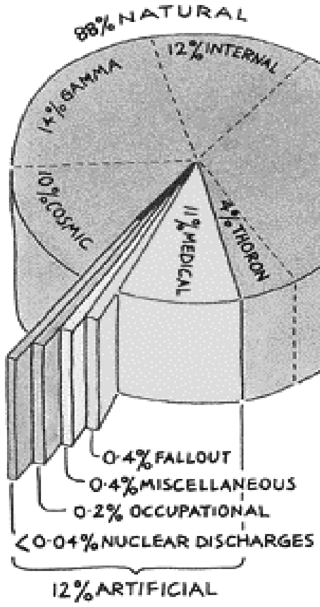


Figure 4 Eric J Hall, "Radiation and Life".

Of all of the ionising radiation to which man is exposed, medical exposures are becoming one of the most important sources. In developed countries, the doses have doubled in the last 10 years.



In medicine, ionising radiation has important applications in both diagnostics and therapy. In most cases those applications are performed on the basis of medical indication. However this is not always the case and considering the relatively high doses that can be involved, all of these exposures should be justified.

Figure 5 Eric J Hall, "Radiation a

Effects

As mentioned before, particles and electromagnetic waves have energy associated with them. When they interact with matter, some of this energy can be deposited as heat. This heat can damage cell material. Another possibility is that the interaction between radiation and matter can result in the production of free radicals. These free radicals are highly reactive and can interfere with the DNA present in cells.

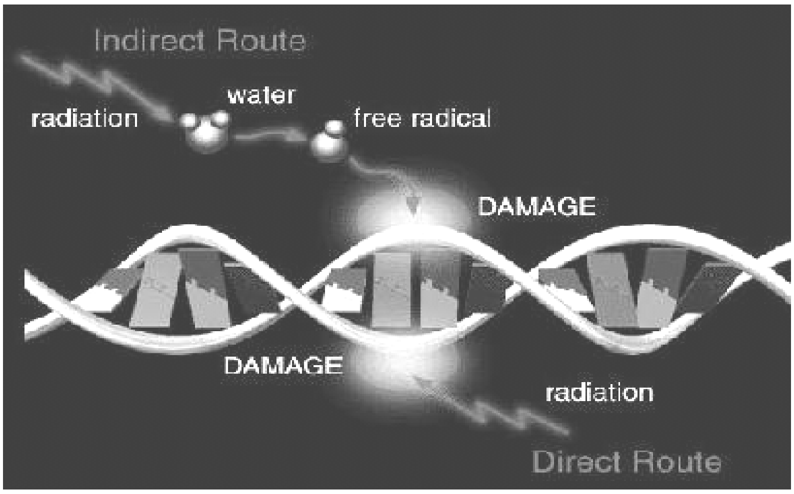
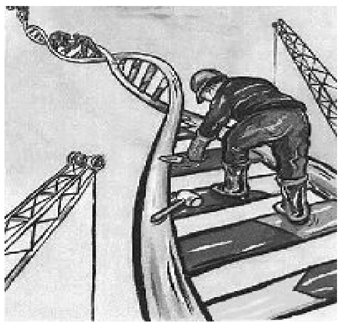


Figure 6 Direct and indirect DNA damage due to radiation

Some damage can be repaired. However, sometimes the damage is irreparable or incorrect repair can occur. When only a single strand in the DNA chain is affected, the damage can be repaired. However, when both strands are damaged close to each other, mistakes can occur in the repair.



Following DNA damage, there are three possibilities:

a The DNA chain repairs correctly and there are no consequences.

b The damage to the DNA (and other parts of the cell) is too severe and the cell dies directly. This happens only at relatively high doses. The consequences are dependant on the organ and the number of cells killed.

c The DNA chain repairs incorrectly which can lead to the induction of tumour cells or to cell death during the next or later cell divisions.

DNA damage due to relatively low doses may cause so called stochastic effects. Stochastic effects can be either tumour induction or genetic effects.
In radiation protection genetic effects are taken into account despite the fact that based on the data from Hiroshima, Nagasaki, and Chernobyl, there is no convincing evidence in humans that these effects can be caused by ionising radiation. However, as it is statistically proven in animals, a cautious approach is adopted and it is assumed that the effect could also occur in humans.

It is estimated that there is a probability of about 5 % per sievert that a tumour will be induced. This can be interpreted as meaning that if 20 million people receive a dose of 1 μSv, tumour induction will result in only one individual, as a result of the ionising radiation.

Cell killing / deterministic effects

Deterministic effects in medical exposures are rare and should not occur at all at the exposure levels, which are typical of those, used for medico-legal exposures. At these latter levels cell killing will not occur.

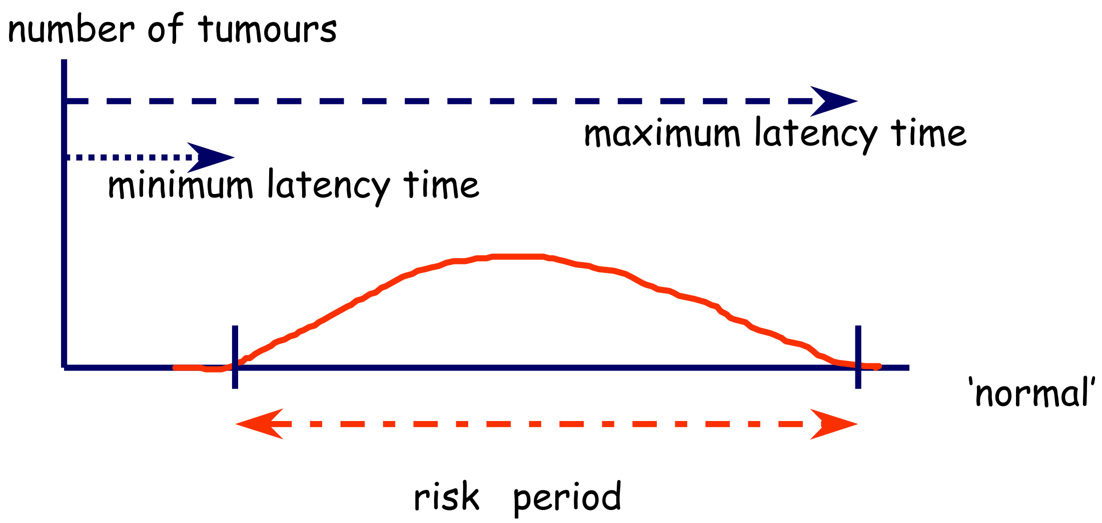
Cell killing due to ionising radiation can cause deterministic effects. If there are only a few cells killed in an organ, there are no clinical consequences. Other cells will divide and the cells killed will be replaced in due time. When somewhat more cells are killed, dysfunction of the organ can occur and permanent damage can arise. If many cells are killed the organ may no longer function, which could be lethal depending on the organ.

Deterministic effects only occur when the dose is above a certain (relatively high) level. The exact level or threshold depends on the organ involved. Adult brain tissues are relatively insensitive to ionising radiation compared to kidneys, which are more radiosensitive. However in both organs, doses of several sieverts are required for effects to be seen. Dose levels of this magnitude would only be likely to be seen in radiotherapy or following a severe accident. If a deterministic effect occurs, the effect will be more severe at higher doses: e.g. in the case of irradiation of the skin, after a few sieverts, there is only redness; at higher levels, firstly there are dry blisters, then wet blisters and finally at high doses, necrosis (death of deep cell layers).

The difference with tumour induction (a stochastic effect) is that while deterministic effects always occur above a certain level, there is only a probability that a tumour occurs at any level of radiation. The probability is dose dependant and is believed to increase with increasing dose.

Latency period

Induced tumours don't appear immediately after the irradiation. Often even tens of years will pass before a clinical tumour may develop. This period is called the latency time and this time is also dependent on the type of organ. e.g. for leukaemia in children the minimum latency time is 2 years and the average 5 years. For bladder cancer the corresponding periods are 15 and 25 years. This is illustrated in the diagram below for the case of leukaemia.



Doses

The terminology and the system of doses are somewhat complicated but are shown schematically below:

Exposure
↓
Absorbed Dose (D) J/kg - Gray (Gy)
↓
$\mathbf{w_R}$
↓
Equivalent Dose (H) Sievert (Sv)
↓
$\mathbf{w_T}$
↓
Effective Dose (E) Sievert (Sv)

When tissue is exposed to ionising radiation, the quantity of radiation absorbed is expressed as the absorbed dose, which has units of J/kg or Gray. In order to take account of the fact that different types of radiation can cause different levels of harm, a radiation weighting factor is used.

♦ **gamma radiation**	**1**
♦ **x-rays**	**1**
♦ **beta (electron)**	**1**
♦ **alpha (2 protons + 2 neutrons)**	**20**

- **neutron (energy dependent) 5, 10 or 20**

The absorbed dose multiplied by the weighting factor, w_R is equal to the equivalent dose. The unit of effective dose is the sievert (Sv).

Not all tissues and organs are equally radiosensitive. In some organs there is a higher chance of introducing tumours than in others. For example, cells that are undergoing rapid division are more sensitive for tumour induction. This makes it complicated to use the equivalent dose as an indicator for damage. There are not only differences between the rate of tumour induction, but also in the lethality of the organ tumours and the years lost due to an induced tumour (e.g. childhood leukaemia versus bladder cancer in 65+ years old). The consequence of all those differences is such that a 100 mSv equivalent dose to the skin has a much lower potential effect than 100 mSv to the lungs.

Therefore another weighting factor is required: the tissue weighting factor.
The equivalent dose is multiplied by the tissue weighting factor to give the effective dose. The unit of effective dose is the sievert (Sv). Most dose limits are expressed in effective dose.

One should recognise that an effective dose of 1 Sv is a very large dose and that such a dose will not be received easily. The doses given in some specific circumstances are:

Sievert (Sv)
- very severe accidents (fire fighters at Chernobyl)
- radiotherapy (patient)

milliSievert (mSv) = 1 thousandth of a Sievert
- dose limits workers (20 mSv) and public (1 mSv)
- medical exposures, mostly below or around 1 mSv per X-ray or nuclear medicine procedure
- CT scan of the abdomen about 30 mSv

microSievert (μSv) = one millionth of a Sievert
- doses due to normal discharges NPP, hospitals etc. < 1 μSv
- effects of Chernobyl in the Netherlands < 80 μSv
- chest x-ray 50-150 μSv

Low dose effects
As mentioned before, even at low doses there is a probability of tumour induction. Moreover it is not certain that there is a linear relationship between the dose received and the probability of an effect. There could be linearity down to zero dose, but it is also possible that at lower doses the effect is relatively smaller or perhaps even beneficial (hormesis theory). None of these theories can be proven because underlying incidence of tumour induction (unrelated to radiation) is of the order of 25-30% during life time. So the additional tumours caused by low doses of ionising radiation cannot be definitively identified.

In radiation protection, a cautious approach is adopted. The recommendations of the International Commission on Radiological Protection (ICRP) are followed and linearity without a threshold dose (LNT) is assumed. However, this LNT curve should never be used to calculate effects after high doses in accidents or radiotherapy. In these cases individual approaches are essential.

This LNT approach gives rise to a specific problem. If many people are exposed as a result of medico-legal exposures, can it be said that the effect of 1000 persons receiving a dose of 1 millisievert is the same as 10 persons receiving 100 mSv? As this question has not been conclusively answered, radiation protection errs on the side of caution and assumes that the answer is yes.

Assuming LNT, one could argue that if 20 million people are irradiated (or 4 million people 5 times) in the airport, assuming a dose of 1 μSv, with a 5% probability of lethal tumour induction per sievert, then theoretically 1 person will die in the coming 10-50 years due to a cancer induced by the X-ray. However the so called collective dose (doses multiplied by number of people exposed) should not be used to calculate risks for very low doses in very large groups, because of the uncertainties about the LNT approach at this dose level.
The question then is: is this justifiable, taking into account the assumed advantages of these controls and taking into account that assuming LNT at this dose level is probably an overestimation.
This brings us back to the central theme of this symposium: the whole issue of medical and medico-legal exposures circles around JUSTIFICATION.

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Current Situation Concerning Medico-legal Exposures in Member States. Results of the Questionnaire

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Introduction

In 1997 the Council Directive 97/43/Euratom on the health protection of individuals against the dangers of ionising radiation in relation to medical exposures (1), the so-called medical exposure directive (MED) was issued. Medico-legal exposures were included in the list of medical exposures and defined as *exposures performed for insurance or legal purposes without a medical indication*. The directive asks for special attention for these exposures with respect to justification and optimisation.

The issue of medico-legal exposures was first brought up at the workshops in Madrid 1998 (2) and in Luxembourg 1999 (3). A request for guidance from Sweden on how to deal with body search by x-rays of suspect smugglers did further add attention on medico-legal exposures. The working party "medical exposures" under the article 31 group has the task of assisting the member states in the implementation of the MED. The WP decided to make a survey on medico-legal practices and to organise a symposium where the results are presented and problems and questions concerning this practice are discussed. Questions such as what types medico-legal exposures do exist, what are the procedures and frequencies in the member states and elsewhere, what is the legal background?

A questionnaire was sent out to the member states in order to obtain the information. The design of the questionnaire as well as its outcome will be presented. Difficulties with the interpretation of the questionnaire and the reliability of the results will be discussed. An outline for improvement of a possible further questionnaire and for further activities in these matters will be given.

Design of the questionnaire

A total of 11 types of exposures that are (or might be) classified as medico-legal exposures were identified and to each of them some 25 questions were asked. The list was compiled according to the best knowledge of the members of the working party. Table 1 shows the types of exposures together with explanations that were provided with the questionnaire as an attempt to harmonise the understanding of what is meant.

Table 1: List of medico-legal exposures that were subject to the survey of practices in Europe

Drugs search in the body	Search **in** the body for drugs
Weapon or drug search on the body	Search **on** the body for weapons, drugs, contrabands etc.
Truck content	Search of a truck or container to discover hidden content
Age assessment	Assessment of age of e.g. asylum seekers
Suspicion of child abuse	Diagnostic for hidden (old) fractures, bleedings etc.
Sportsmen	Regular preventive diagnostic of sportsmen, health status in connection with transfers, diagnosis of bone cartilage to predict growth (and length) for dancers, basket ball players etc.
Insurance	Diagnostics to find hidden, latent diseases to protect the insurance company, e.g. as condition for life or health insurance of the person in question
Civil Litigation	Diagnostics to find presence or absence of injuries or diseases to be used as evidence in court proceedings
Immigration or Emigration	Diagnostics for hidden diseases in immigrants or emigrants, e.g. of tuberculosis
Prisoners	Diagnostics to detect swallowed objects, swallowed for escape purposes, smuggling into or out of the prison
Pre-employment procedures	Diagnostics to find hidden, latent diseases to protect the employer for 'miss-buying' Idea to protect co-employees, school children etc. against infection.
Others	

The questions for each medico-legal procedure can be grouped into 5 groups.

1. Basic information

1. Is this exposure performed in your country?
2. Does the answer describe the present situation or the near future?
3. Performed with what frequency?
4. Is this exposure the first choice?

2. Involvement of Exposed Person

1. If performed, is it on a voluntary basis?
2. What happens if the person refuses?
3. Is a written informed consent required?
4. Would you in your country call this a medico-legal, medical, occupational exposure or other?

3. Legal provisions

1. Is there a legal provision covering this practice?
2. If yes is this provision specific or adapted to this practice?
3. Is there a specific written procedure (how to perform the exposure)?
4. Which is or are the competent authority or authorities for this practice?

4. Conduct of the exposure itself

1. Who takes the actual decision (justification) for a specific exposure?

2. Where is the examination performed?
3. Who is responsible for the exposure itself (who is the practitioner acc. to the MED)?
4. Is the practitioner present when the exposure is done?
5. Who is actually exposing (pressing the button)?
6. Does this person have a specific training for this purpose? (including optimisation)?

5. Equipment

1. Is there specific equipment used for this exposure?
2. If yes, specify the type?
3. If not, which type is used?
4. Is the equipment licensed or reported to competent authorities?
5. Who is responsible for its maintenance and/or quality control?
6. Is there a qualified expert for this practice on the site?
7. Are dose assessments made?
8. If yes, what is the approximate dose (μSv)?

RESULTS OF THE ENQUIRY

The questionnaire was send to all Member states in the European Union and to two countries outside the EU. Eleven MS and the two outside the EU filled in the questionnaire, two announced their inability to answer and two didn't respond at all.

Practices with medico-legal exposures

Some of the eleven medico-legal procedures are reported to be performed in all countries (drug search, child abuse, civil litigation). Search of trucks and search of weapons on the body were claimed to be performed in five countries out of thirteen. However, a closer analysis of the answers revealed that search of weapons actually is performed in only one of these countries. X-ray checks of luggage and metal detectors were erroneously classified as weapon search in the meaning of the questionnaire.

The remaining procedures are performed in a number of countries in between, on average in ten countries out of thirteen, and no examples for additional medico-legal procedures were given. All the answers were referring to the present situation. Frequencies for how often these exposures were performed are given only occasional. The data need to be scrutinized before drawing conclusions because some of the answers indicate that the questions were not properly understood are that the person answering wasn't aware of the situation in his/her country. This is underlined by the fact that when different individuals responded for one and the same country contradictory answers were given for whether or not these procedures are practiced.

Involvement of the exposed person

For the vast majority of the exposures it is claimed that they are performed on a voluntary basis, but in only 10-20% of the cases a written informed consent is required. In practice, however, the degree of freedom of choice is quite different for the various practices and in the various countries. In the examples of exposures related to immigrants/emigrants, pre-employment, insurance and civil litigations the alternative to giving consent for a radiological examination could be to the disadvantage of the person to be exposed – no immigration, no employment, no insurance or shorter odds for winning in court cases. For child abuse exposures a judge might overrule the refusal. Suspected drug swallowers are taken into custody until nature takes its course.

Legal framework

For most countries it was claimed for the majority of procedures that legal provision exists. For about half of the procedures and countries these legal provisions were classified as specific provisions. Provided that the intention of the questions in the questionnaire was well understood the results would reflect the legal system in the respective country: whether it is based on a legislation giving the general outline and where the details are given in guidelines or are set locally. In less than 20 % a specific written procedure exists.

As competent authority for the crime related procedures drug, weapon and truck search mostly customs, police and/or judges were mentioned, and for the other exposures predominantly health authorities. Sometimes several authorities were mentioned for one and the same exposure, e.g. justice and health for child abuse.

Conduct of the exposure itself

Mostly a radiologist or other medical doctor is deciding about the exposure. For crime related examinations this is normally the judge, police and/or the customs. There is no information about what would happen if e.g. the judge is deciding upon a medical exposure and the radiologist would refuse.

With the exception of weapon search and trucks almost all examinations are conducted in a normal hospital or equivalent with ordinary medical x-ray equipment. That means that all the subsequent questions were not to be answered, the procedures are following those of normal medical x-ray diagnostics.

The conditions for truck examinations are quite homogenous between the reporting countries: The customs/police is responsible for the exposure and is also performing the exposure itself and has special training for that purpose. The same is valid for weapon search. But, as mentioned above, obviously only one out of five countries quoting the conduct of such procedures is really performing such examinations, using body scan backscatter equipment. Weapon search on the body could hardly be performed with the other equipments quoted: medical x-ray equipment, handhold detectors and equipment specific for check of luggage.

No single a single numerical value for the dose was given. Some references were made to national data for corresponding medical x-ray examinations.

Discussion

The intention with sending out the questionnaire was to map as complete as possible the situation with medico-legal exposures, in the first place in the member states of the European Union. The analysis of the responses has revealed large gaps in the information, and also obvious erroneous statements. There are several reasons.

1. Some of the terms were misinterpreted. Examples for that are the pre-employment exposures that were thought to include examinations related to health risks from the occupation itself (e.g. screening miners for silicosis).

2. Some of the questions asked were not clear enough and could be interpreted in different ways. The legal framework has certainly branches in several domains, in the

criminal code, health care legislation and radiation protection regulations that in some countries are standing by its own.

3. Some of the topics are complex and will not allow just a single answer. Exposures for sportsmen can be given for several widely different purposes, e.g. to exclude abnormalities that would contradict exercise in certain sports, to follow the growth of children in order to adapt training in the most effective way, to check health status at transfers of top football players.

4. There are borderline cases that are very difficult to classify, such as preventive medicine versus medico-legal exposures.

5. Obviously there are difficulties in every country to obtain information about these activities outside the normal medical practices. It's not clear whether the main problem is that the radiation protection people (the ones in charge to gather the information for the questionnaire) don't have the proper channels e.g. to the customs or to the judicial system. Or it might be so that there is no nation-wide coherent view about these activities; they are performed locally without co-ordination concerning the legal and practical procedures.

However, despite these drawbacks we got a fairly good view on the situation in the EU. All the procedures listed are performed and there is a legal framework regulating them. The majority of all exposures are performed in a hospital with the radiation protection system that is established there.

Conclusions

Medico-legal procedures are performed in all countries, however with a different extent. Some types of these procedures are conducted in all countries that responded to the questionnaire, others in just a few. The legal background and the praxis of how these procedures are carried out are varying considerably. Little is known on the frequencies in most countries. Neither do the results allow a judgement on where the largest impacts for radiation protection actions might be. Nevertheless, some advice can be given for future activities in this field.

1. A network between the radiation protection authorities and other authorities involved in the actual medico-legal procedure should be established, including also the professions involved.

2. A refined questionnaire should be designed and maybe send out directly to the authorities involved.

3. European guidelines should be established for some of the procedures that contain difficult ethical aspects (e.g. search of suspects with very low doses) or are very delicate (e.g. child abuse).

The authors are well aware of the difficulties that exist when trying to obtain information about medico-legal procedures. They want to thank all of you who put so much effort into this matter and thus provided them with a solid starting point for future actions.

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Session II – Exposure of Children, Health Determination

Radiological Age Assessment of Children and Adolescents: Usefulness and Precision of Methods versus Delivered Irradiation

JF Chateil, E Marshall-Depommier, C Douws, S Gromb, G Kalifa – France

We have to answer to several questions to define the topic of this subject:
- The first one is relative to the subjects, who are concerning by such studies.
- In the second part of this text, I will try to appreciate the techniques and their accuracy, and which trust we can have in such practices. This part will be a little bit descriptive, but it is necessary to well understand the limits of our tools.
- Then some indication about the level of irradiation of radiological studies will be given.

Finally, all these data will be summarized some guidelines about that practice will be proposed.

When is there a need for age determination in childhood, in the name of the law?
In living people, especially in childhood, in most of cases, such request is made when there is no valid proof of date of birth: It could be for an adoption, in infants. In older children and young people, the requests may be for young refugees seeking asylum or Illegal immigrants. In the practice of a paediatric radiologist, the most frequent request concerns teenagers who are near 18 years-old and for whom the police needs to know if the adult penal law could be applicable in case of offence.

Which medical method can be used for that evaluation?
The physical examination is always the first step, but it is quite imprecise to give an exact determination of the age of the child: height, weight, psycho-intellectual development and pubertal criteria represent some indicators but are still variable. Dental status by a dentist can also help, but imaging studies are in most often cases required.
Two types of methods are still available:
- Dental age is based on the radiological evaluation of baby and adult teeth.
- Skeletal maturation is evaluated by different methods: number and shape of ossification centres, fusion of metaphysis in long bones, and presence of secondary apophysis centres. To perform these imaging studies, one part of the skeleton has to be evaluated with X-rays. So the first tool is an X-ray tube and an imaging device. Once the exposure performed, a radiologist or a forensic doctor has to do the report. This activity needs experience, because there are some pitfalls.

To be acceptable, the employed method has to fit with elementary principles: It has to be transparent and provable, reproducible and non-dependant from the reader. Clear information concerning the technical realisation has to be available. The results and their accuracy must be confirmed by publications with statistical analysis (1). One important point is the respect of principles of medical ethics in living individuals. To better understand the benefits and the limits of these methods, we have to explain some of them, to know in which case they can be useful.

Dental age determination is based on the radiography of the mandible. This is called an orthopantomogram. This technique needs a relatively "long" exposure, about 5 seconds; during this time, the patient has to keep quite, so this radiography can be realised in children aged of 4 years or more. The relative proximity of the eyes and of the neck provides some irradiation to the lens and to the thyroid.

All the teeth are clearly demonstrated on the view obtained. The age determination is based on the presence of the teeth (baby and adult teeth) and their maturation, crown and roots. It can be used from the first years of life to 21 year-old.

Some specific tables permit the interpretation of the dental age. In the first years of life, differences between two steps are clearly visible, and the interval is rather short. But for the last steps, it is more difficult because the time interval is larger and larger. So there is a need for a more accurate evaluation.

During adolescence, the shape of the roots of the second and of the third molars had to be analysed. Ten grades have been described. Some authors studied also the size of the dental canal and compared it to the width of the root.
What are the accuracy and the limits of these methods? Every publication notes that the age determination is difficult between 16 and 21 year-old and quite uncertain during adolescence (2). For some people, there is an overestimation of more than 1 year, for another one the error is between 9 months and 3 years.

The second type of studies is based on the **evaluation of bone maturity with X-rays**, at any part of the skeleton. The first studies are very old, more than one century, just after discover of X-rays by Roentgen. The first keys of bony age determination were given at that moment, as, for example, the more precocious maturation of bones in girls. Large studies in normal children were conducted from 1920 to 1950; this was before the knowledge about radiation effects. So, current standards for sequential maturation are now 50 year-old and the question about their availability can be asked. Most of these studies were also performed in Caucasian subjects, and the standard is not necessary the same in other ethnics.

Several examples of radiological examinations that can be used for age determination will be described:
* The hand and wrist, mainly with Greulich & Pyle method, but also with the software of Sempé.
* The elbow has been highlighted by Nahum & Sauvegrain.
* The Risser's test concerns the iliac crest;
* And Kreitner has studied the clavicle with computed tomography.

The view of the hand and wrist is easy to perform and need only one exposure. It can be used from 2 to 18 years-old. The age determination is based on the number of ossification points and the morphology of carpal bones, the epiphysis. The radiologist has to analyse each bone of fingers, and to look about carpal bones. This report is done by comparison of the radiological view with the atlas of Greulich & Pyle. This one displays on each page one example for each age, different for boys and girls. On the left page there are some guidelines to help the reader, with remarkable details changing from the previous page to the present one. But there are some difficulties and traps with Greulich & Pyle atlas: The admitted standard error is ± 1 year during puberty and at the end of the growth. Another frequently asked question in forensic evaluation is to know if these standards are applicable to any population, particularly with migrant people. In this case, data in the literature are not concordant: some studies demonstrate an underestimation, and others an overestimation. These differences could be in relation with the ethnicity of the people or with different status regarding nutrition, healthcare.

Other methods have been developed with the use of radiography of the hand and carpal bones. Sempé, in France, has written software (whose name is Maturos), working on PC or Mac computers, which is a good tool to improve the accuracy of the method. The reader has to compare the image obtained with the subject to drawings and X-rays displayed on the screen. For each step of the maturation, some details are given to help the differentiation between two aspects. For each bone of the hand and the wrist, the good level has to be chosen. It is time consuming; it allows getting an evaluation for each bone and a global result.

At the peri-pubertal age, we saw that the evaluation on bone maturation is quite difficult with the radiography of the hand. Others authors try to develop complementary methods, to help the reader in this interval of age. The **radiography of the elbow** is a good tool between 9 to 13 years old (Nahum and Sauvegrain). This study needs two exposures, an A.P. view and a lateral view to evaluate the presence and the maturation of the condyles, the radial capita and the proximal point of the ulna. A score is calculated and reported on a curve.

To have other information about the bone age of a subject, some authors define the aspects of the maturation of the secondary ossification centre of the iliac crest. This study, whose name is **Risser's test**, is available between 12 to 16 years-old. 6 steps have been defined and may help to determine the age in adolescence. The main criticism concerns the topography of this point, because the evaluation requires a radiograph of the pelvic girdle, and the irradiation delivered to the gonad has to be considered.

The last method to illustrate is the study of the clavicle (3). The age determination is based on the presence and morphology of the medial secondary ossification centre of the clavicle: this one appears at 12 and is assimilated to the adjacent bone at 25 years. This secondary ossification point is rather difficult to evaluate with plain films, and a German author proposed another method with computed tomography. The four grades of the maturation of the clavicle are illustrated with CT. The interval between each grade is quite large. If the grade 4 is reached, the age of the subject is over 22 years, and that could be sufficient to affirm that the patient has to be considered as an adult.

The **accuracy of the radiological methods** is between ± 6 months and ± one year of precision. This gap represents a possible error from one to 2 years.

There are also some limits: even if the method is well described, some variations between readers are observed. Variability in different populations has been observed (4, 5). It could be in relation with the ethnicity and with socio-economic conditions (6, 7). For example, the population in North Africa seems to have a more rapid bone maturation. On the other hand, malnutrition could be responsible of a delay in this maturation (8). This delay disappears after a few years when the subject is living with more comfortable conditions.

Which one of these methods is used today?

There are no legal obligations in most European countries to use one method instead of another one. To get an overview of practices in France, a survey has been performed by Email send to all the radiologists involved in paediatric radiology. Here are some results:
This type of request is rare, but seems to be more and more frequent in the last years.
In most of cases, the radiologist has to answer to legal requisition by judge or policemen.
The employed methods are the following:
- Hand & wrist is the first one, with Greulich & Pyle atlas, and in some cases with Maturos software.
- In the other cases, iliac crest and clavicle are studied.
- The dental age seems to be less often evaluated.
The results given in the report are also of interest. The margin of error varies from 6 months to one year. A lot of radiologists add the following condition, "regarding the ethnic origin and or the socio-economic conditions of the subject". Many people note that in case of adolescent round 18, the evaluation is very difficult; in these cases, they think that their help is rather poor.

Level of irradiation delivered by such examinations.
This one can be different among the techniques, the practice, even with the same method. A few years ago, a study of the EEC for the delivered irradiation in children demonstrated that this one can vary on a very large scale, from 1 to 80 for example for an A.P view of the pelvic girdle in infants.
The following level of delivered doses can be considered:
- For an A-P view of the hand and wrist on Plain X-ray: 0.15 mGy.
- For an orthopantomogram, the delivered dose to the on the neck 0.56 mGy, thyroid gland 0.053 mGy (9).

To appreciate the level of the dose of irradiation, we could compare them with other situations. For example a plain X-ray of the hand and wrist gives an irradiation that is comparable with 15 days in mountain at 2000 meters of altitude. An orthopantomogram is responsible of a delivered dose equivalent to one month of mountain stay at the same altitude.

Alternative methods to using X ray
Sonography of the hip has been suggested; one technique for example measures the thickness of the head articular cartilage (10). The technique is safe, without irradiation. It is reproducible between observers. But the precision is not very good: 4 to 5 years. There is a need for improvement of such techniques.

Guidelines to remember
First of all, radiological methods are not absolutely precise, and lawyers have to know these limits.
Currently, the following techniques can be proposed in such cases:
- X-rays studies of bone maturation need the study of the hand and wrist. Dental studies could be performed separately, with a trained practitioner.
- The study of the clavicle with CT can help to determine if the subject is over 22 years-old.
- Irradiation has to be "as low as reasonable achievable", in agreement with the general guidelines used in paediatric radiology. Radiologists have to remember the rules of radioprotection for the subject such as the correct use of diaphragms, low mAs, rapid screens and films. In most cases only one incidence has to be performed if possible. Lastly the repetition of radiological studies for the same subject has to be avoided.

The last guideline concerns the development of new studies with non-irradiating techniques: We have seen one example with sonography: perhaps are there some other studies to perform, to find and validate new data.
In other cases, Magnetic Resonance Imaging could also help for bony age determination; it is more expansive but any part of the body can be imaged. But no data is actually available to assess the value of bone age determination with such method.

In conclusion, the main points are:
First of all, radiological methods are not perfect; In case of doubt, estimation should be favourable to the subject (in most of cases, it will be an underestimation). This rule is a medical rule: "primum non nocere".

Secondary, the delivered irradiation is low if the exam is performed with a good practice. The expositions have not to be repeated. With these precautions, any side effects in relation with irradiation have been encountered at this level. But we have to remember that people in this population are young, and we can ask to the lawyer for each subject if the radiological evaluation in that case will be really helpful. This is the principle of justification applied to this request.

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Exposures in the Name of the Law (Sports Radiology)

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"The primary aim of radiological protection is to provide an appropriate standard of protection for man without unduly limiting the beneficial practices giving rise to radiation exposure. This aim cannot be achieved on the basis of scientific concepts alone. All those concerned with radiological protection have to make value judgements about the relative importance of different kinds of risk and the balancing of risks and benefits."(1)
Justification and optimisation of radiological exposures is required under Euratom Directive (MED) which was introduced into legislation in 2000. Radiology is a referral speciality. The injured athlete, either amateur or professional, is examined by the referring doctor (prescriber) and is referred to another doctor, radiologist (practioner) for a radiological opinion and/or further imaging. The justification process is further enhanced by the involvement of a radiographer with knowledge of radiation safety who produces the images.

Imaging is appropriate in sports medicine as in general medicine and surgery when the result, (positive or negative) will influence patient management. It should be noted that a negative test is reassuring to the patient and referring doctor.

Imaging is specifically indicated when;-
The clinical diagnosis is uncertain.
When the clinical diagnosis is obvious but there may be a complication.
When therapy has failed and the cause for this is being sought.
Where there is a requirement for objective assessment of disease existence, progression or resolution as may be required for medico legal purposes.
To exclude pathology unrelated to sports injury e.g. malignancy or infection.

Imaging techniques available for sports injuries include radiation techniques, e.g. plain x-rays, CT scanning, Isotope Bone Scans and DEXA (Bone Mineral Analysis) and alternative techniques, e.g.. Ultrasound, and MRI. Radiological and non radiological imaging techniques are often complimentary and are not necessarily mutually exclusive in the diagnosis of sports injuries.

Usually a detailed clinical examination is carried out by a doctor with an interest in sports medicine. It should be noted that sports medicine is now a recognised speciality in many European countries. Radiological examination of the affected part usually progresses from the less to the more sophisticated modalities. The starting point is often with a **plain X-ray**. "A high quality plain X-ray examination will provide a detailed and panoramic overview of both bone and soft tissue anatomy in a recognisable format and at low cost. Basic errors will be made if the humble plain film is bypassed in favour of more sophisticated tests alone (2). Many sporting injuries involve the extremities and exposure to ionising radiation in these cases can be limited to the affected part by good radiographic technique

Isotope Bone Scanning provides a functional image of skeletal osteoblastic activity and is a sensitive but non specific technique requiring comparison with other modalities, e.g.. Plain X-rays, CT, MRI, etc. Some scans however are characteristic, e.g. long bone stress injuries of the tibia and fibula in athletes complaining of shin splints.

Computerised tomography (CT) scanning shows cortical and trabecular architecture of bone well.
It is good for revealing the bony anatomy of complex joints and it is better than MRI for the demonstration of fracture lines, calcifications, loose bodies and bony erosions and can be used for assessing bone mineral loss. **DEXA** scanning is usually a very low radiation dose technique for assessing bone mineral in athletes who may be susceptible to osteoporosis, e.g. young female athletes and older patients who may be embarking on unaccustomed sporting activities.

Optimisation includes the utilisation of techniques alternative to radiation techniques, e.g. MRI and Ultrasound.

Ultrasound is a useful technique for the assessment of superficial tendon and ligamentous damage and is excellent for the demonstration of fluid collections and for imaging of blood vessels. It may also be used for bone mineral analysis screening. It is however operator dependent.

MRI resolves bone mineral poorly but is excellent for demonstrating cellular bone marrow and thus is useful in the diagnosis of avascular necrosis, bone bruising and bone stress. It is also excellent for the demonstration of cartilage, e.g. herniated discs in the spine and meniscal tears in the knee where MRI examination may be combined with arthrography using gadolinium contrast agents.

In general, imaging for sports injuries falls into 3 categories:-

(1) Acute injuries e.g.. fracture of a long bone, skull or spine arising from a sporting injury, these are treated as injuries arising from any other source. There was a clear benefit to the athlete/patient which surpasses any risk arising from the radiation exposure.

(2) Chronic injuries usually arising from prolonged or unaccustomed involvement in sport. Radiological investigation requires close correlation of imaging techniques by the radiologist in discussion with the referring sports physician. These are often distressing for the athlete particularly when the injury prevents participation in sporting activity.
Chronic sports injuries include overuse injuries which are common and account for 30 – 50% of all sports related conditions and 50 – 75% of all running injuries. Overuse injuries may be acute or chronic and are due to repetitive precipitating activity which overwhelms the process of tissue repair. They are often associated with a change in type or degree of athletic activity and there is usually a delay in clinical presentation. Bone is a metabolically active tissue, and chronic bone stress occurs when resorption exceeds new bone formation. The early changes can be shown on Isotope Bone Scans and fat surpressed MRI but later changes are evident on T1 and T2 weighted MRI images. Later still, stress fractures develop and may proceed to full fracture if trauma continues. There are two sub types: (A) Fatigue fracture which occurs in

elite athletes and (B) insufficiency fracture usually occurring in athletes with pre existing unrecognised osteoporosis.

Stress fractures tend to occur at particular sites e.g. distal fibula, mid shaft, tibia in basketball players and long distance runners and pars interarticularis of the lumbar spine, usually L5/S1 level in ballet dancers, footballers and weight lifters. Avulsion injuries form another distinct group of chronic sports injuries. These tend to occur at, among other sites, the symphysis pubis and anterior inferior iliac spine in footballers and at the ischial apophysis in hurdlers, fencers, footballers, and dancers.

Musculo-skeletal injuries are particularly problematic in childhood and adolescence. The bio mechanics are the same as adults but the joints and growing ends of the bones are vulnerable and injuries may have long term consequences in later life, e.g. the development of degenerative arthritis. Early diagnosis and proper treatment are of a paramount importance.

(3) Screening of athletes for the presence or exclusion of particular injuries arising from various sporting activities. This situation may arise with elite or professional athletes or sports people.

Radiological screening of asymptomatic athletes is probably unnecessary but some sports have specific associated injuries and it may be that focused screening of these locations is appropriate in elite or professional athletes. In the case of professional athletes the athlete should have the prerogative of choosing between the risk of radiation exposure and the potential benefit of confirming or excluding an injury which may affect the athlete's livelihood.

In conclusion: Plain film, CT and Isotope Bone scans play an important role in acute and chronic sports injuries. Many injuries are localised to the limbs and require low exposures. There is increasing use of alternative techniques e.g. MRI and Ultrasound. The referral practice of radiology provides a radiation safety net and underpins the justification and optimisation process.

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Imaging Of Suspected Child Abuse – Ethical And Radiation Issues

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Abstract

Child abuse is present in all societies in the world, but it takes many forms. Child abuse may occur by acts of omission such as physical and emotional deprivation, both of which may be extreme. Acts of commission include physical and sexual abuse. Children who are sexually abused rarely present for imaging. Physical abuse may be superficial, e.g. bruising, burns, or affect internal organs – bones, brain, eyes, thorax and abdomen. The role of imaging is mainly concerned with physical abuse.

The medical and social management of suspected abuse varies greatly across Europe. In the U.K., once abuse is suspected on appropriate clinical grounds, there is an obligation for referral to the social services to ensure that the interests and safety of the child are placed first.

The diagnosis of child abuse may be straightforward. The complete evidence for abuse often involves social and clinical findings, supported by radiological evidence. It is with the latter that we are concerned in this meeting.

Once abuse is suspected, in children under the age of two, the care pathways involve a request for a skeletal survey supplemented by neuroimaging in many infants. The aim is to identify occult injury not clinically evident. The age of two is regarded as the watershed. After this, the detection of occult fractures diminishes – mainly because the mechanisms of injury change. Once a decision is made to perform a skeletal survey, it must be done properly. The images must be correctly exposed, well centred and cover the whole skeleton. A survey should include two views of the skull, with a Towne's if there is occipital injury, chest, AP view both upper limbs, lateral spine, abdomen/pelvis, AP hands and feet, AP lower limbs and AP and lateral view of knees and ankles. Many would add oblique views of the ribs to this list, and repeat the chest and knee and ankle views in 10 days. The radiation dose will depend on the radiographic technique, film/screen combination, CR or DR – v – conventional film/screen images.

Radionuclide scanning is often used as a substitute for the survey. It is not an acceptable alternative – skull fractures, and metaphyseal fractures may be, and are often, missed. It is an excellent additional investigation. If done, the technique must be meticulous – good quality, still images – not "baby gram" images, limbs imaged separate from the chest and abdomen. To achieve these images, the child will probably need sedation on GA and may need bladder emptying by catheter. The ethics of doing this scan under these conditions must be questioned unless there is a significant increased diagnostic yield.

If there is suspected lung injury or trauma to the intra abdominal organs, most doctors will now use CT for the primary screen, with follow up by ultrasound. The technique of CT

greatly influences radiation dose. For neuroimaging, in the acute situation, CT is the universally available and logistically easiest technique, although where facilities are available, MR diffusion weighted imaging, together with standard MR, has an increasing role. Pitfalls of early MR include failure to identify acute bleeds.

Issues that will be addressed are the pros and cons of the different imaging techniques, the risk/benefit to the child, the question of sibling imaging and repeat imaging.

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Session III – Preventing Illegal Activities

Backscatter Techniques – An Alternative to Body Search

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Abstract
The AS&E BodySearch™ system is an x-ray scanning system which uses backscatter x-ray to form an image of a subject as he/she stands next to the system. Operationally, a pencil beam of x-rays is generated by a rotating chopper wheel, which scans horizontally as it is moved in the vertical direction. X-ray detectors mounted adjacent and parallel to the direction of the scanning x-ray beam collect the scattered radiation. The result is a photo-like image of the body surface facing the system. The use of a scanning pencil beam in a backscatter geometry with a 140 kV x-ray source eliminates any issue of radiation safety. In fact, the dose delivered by the system (less than 5 microrem per inspection) is less than 1% of the dose a person standing outside at sea level receives from background radiation in a day.

Introduction
There are several methods available for performing human inspections, and they vary widely in their tradeoffs between effectiveness and intrusiveness. The most widely practiced methods are also the least intrusive: Walk-through metal detectors and pat-down searches. Because these types of searches are relatively unobtrusive, the barriers to implementation are low. However, their ability to detect a wide range of concealed materials is limited. The far more intrusive strip-search is probably the most effective search technique available, but for obvious reasons it is only practicable in a restricted number of environments, such as a prison. This technique is not only intrusive and degrading to the subjects, but it also places the operators in close quarters with the subjects, exposing them to the personal risk of disease transmission and bodily violence. These issues force security agents to be very restrictive in their use of strip-searches, relying instead on intuition as a means of pre-screening individuals.

Naturally this very subjective process drastically reduces the effectiveness of the interdiction effort. New technological tools such as x-ray imaging, electromagnetic imaging, and trace detection are now becoming available to increase effectiveness while limiting intrusiveness. Of course each of these technologies has its advantages and disadvantages. American Science and Engineering, Inc. (AS&E®) has developed what it believes to be the best solution available to date in its BodySearch™ X-ray Inspection System. BodySearch (shown in Figure 1) uses backscatter x-ray imaging to quickly and safely acquire high resolution images sensitive to both high atomic number (high-Z) metals and low-Z organics and explosives concealed on the body with minimal inconvenience and intrusion to the subject.

The AS&E BODYSEARCH™ System

To perform a scan, the subject is asked to stand relatively still on an external stage for several seconds while the system acquires two-dimensional raster-scanned image data. The electronic image of the subject is formed using the intensity of x-rays scattered from each location on the body via Compton scattering interactions. This x-ray scatter intensity is a function of both the atomic number and density of the materials probed by the primary x-ray beam, in this case either the body itself or items worn on the body. Note that since hair and clothing have very low densities, very few x-rays interact with these materials and they effectively vanish from the image. Denser objects such as metals, explosives, plastics, and packed drugs interact more strongly and so appear in the image along with the body itself. This can be seen in Figure 2, which shows examples of both metal and organic items on the body imaged with x-rays. The tight collimation of the x-ray beam results in high spatial resolution in the acquired images, making identification of the objects on the body easier. Note, however, that this technique only images materials on the surface of the body. It is not effective for seeing through the body or detecting materials which are concealed within body cavities. Because of this fact, two scans (front and back) are typically required for a routine inspection. Additional scans can in some cases be beneficial for identifying objects on the body. This is an area where the training and experience of the system operators can be important in maximizing system effectiveness.

Figure 1 The AS&E BodySearch System.

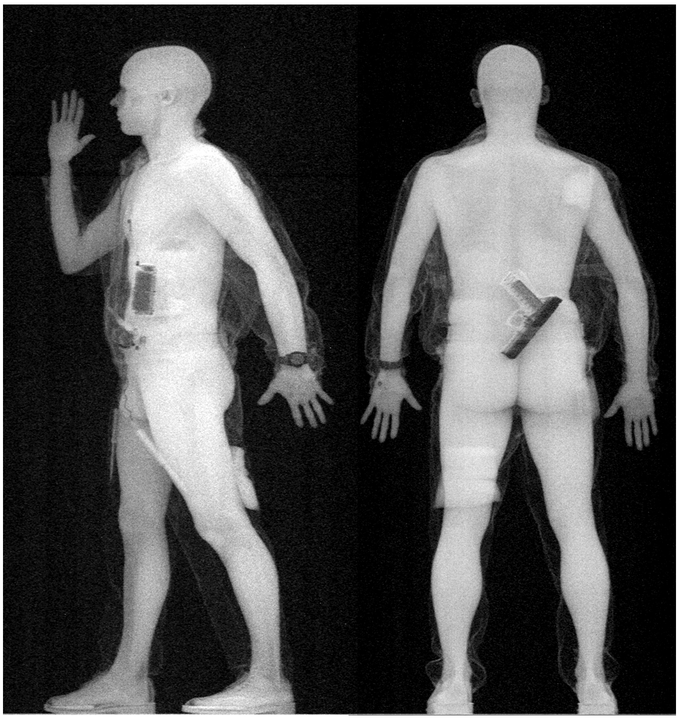

Figure 2 Images taken with the AS&E BodySearch system. Metallic objects appear dark when viewed against the body. Concealed organic objects appear as bright regions in the image.

Maximising System Effectiveness

In the majority of cases, a simple front and back view of the person being inspected is sufficient to determine the presence or absence (and in many cases the identity) of contraband on the body. Extracting that extra percentage of detection sensitivity, though, requires slightly more. As is the case with virtually all x-ray imaging systems, the operator interpreting the acquired images is a vital component in the overall performance and effectiveness of the system. This is clearly the case with the BodySearch system. For maximum effectiveness, the operator must know not only how to interpret the images but how best to position the subjects being scanned for the best view of potential contraband. This is not a difficult task to learn, but is simply a matter of operator training. First comes an understanding of how different materials appear in an x-ray image when placed against or alongside the body. As a rough rule of thumb, materials with high atomic number (high-Z) such as metals are good absorbers of x-rays, and so appear in the image as dark areas corresponding to few scattered x-rays. Conversely, low-Z materials (drugs, explosives, and the body itself) are good sources of scattered x-rays, and so appear as bright areas in the image corresponding to a large number of scattered x-rays. Since objects show up best when presented with a contrasting background, the most revealing view of dark, high-Z objects occurs when they are positioned in front of the bright signal from the body. Likewise, bright, low-Z objects are easiest to detect when imaged alongside the body so that they are contrasted against the dark air background. These are ideal conditions which produce the greatest detection sensitivity. However, the operator can not always expect these conditions to occur. This is where operator training becomes so important. When low-Z objects are imaged against the body, that is, white-on-white, there are still fairly obvious indications in the image if one knows what to look for. Changes in brightness level often reveal areas that are distinguishable as foreign materials on the body. Many low-Z threats appear this way because they have a density that is different from that of the body, resulting in a difference in grey-scale in the image. Even more useful is a "shadowing" effect which usually outlines a foreign object. Because of the very small spatial extent of the primary x-ray beam, x-rays which scatter from the body immediately next to a foreign object are somewhat shielded by that object, resulting in a darker grey-scale in the image for that given pixel. This occurs all around the object and tends to outline its shape with a "shadow." Figure 3 shows a non-metallic gun placed against the body and illustrates the shadowing effect around the object. Operators using the BodySearch system quickly become accustomed to what a normal body without contraband looks like in x-rays, such that these visual cues are easy to recognize. This is facilitated by the fact that many foreign objects on the body such as packets of drugs, moulded explosives, and plastic items usually have straight edges, right angles, or uniform curvatures to their shape. These shapes are not natural on the human body and immediately draw the attention of operators who know what to look for. Once operators are trained to look for these signs, even small, subtle objects in the image can be detected which might otherwise have gone unnoticed. A skilled operator will then re-position the person being inspected so that potential low-Z threats will be presented to the system in silhouette against the air back-ground, permitting more certain detection and identification.

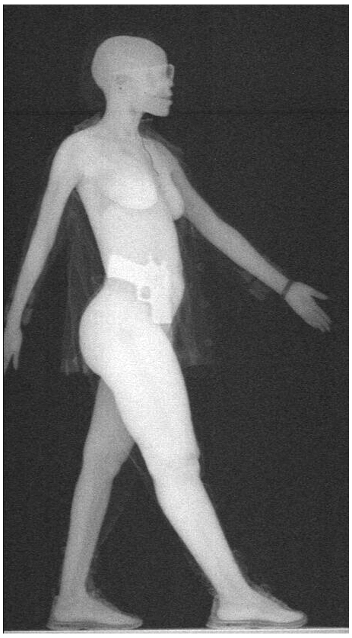

Figure 3 The shadowing effect is clearly seen around the concealed non-metallic gun.

This same procedure can be exercised for high-Z materials imaged alongside the body against a poorly contrasting air background. While air produces little x-ray scatter, it produces enough to contrast against metal objects, given the right tools with which to view them The BodySearch system is equipped with image enhancement features which, among other things, allow the operator to enhance regions of the image containing very low signal levels. This helps to take advantage of the small but useable contrast between metals and the air background making it easier to distinguish the presence of metal items. A skilled operator will use this tool and in these cases re-position the subject for imaging of the object using the body as a backdrop.

Health and Safety

The BodySearch system exposes the subject being scanned to only 5 μrem (0.05 μSv) per scan, which is an extremely low exposure. By way of comparison, the typical natural background radiation exposure (at sea level) that we are all exposed to is approximately 550 μrem per day, or the equivalent of 110 BodySearch scans per day. Put another way, the deep-body dose received from ingesting the radioactive potassium from a single banana is about 6 μrem, which is a little more than that received from a BodySearch scan. Another interesting comparison can be made to the radiation exposure received during air travel. The exposure received during a round-trip flight from New York to Los Angeles is roughly equivalent to 1000 BodySearch scans. The safety of the BodySearch system for general use even in applications where multiple scans are performed on persons as an everyday routine has been confirmed by independent health physicists, and the BodySearch system has met all of the compliance requirements set forth by the U.S. FDA for entry into commerce.

Detection Capabilities

The detection capabilities of the BodySearch system are naturally dependent on the skill of the operator interpreting the images and can vary depending on the body type of the subject. Because of this difficulty in creating repeatable controlled test conditions, it is not as easy to quantify absolute detection limits for the BodySearch system as it is for other types of x-ray inspection systems. To address this, AS&E has performed a series of tests to make the best determination possible of realistic detection capabilities under given conditions. These conditions are: a) the operator viewing the images has a reasonably good understanding of how different materials appear in the x-ray image, is reasonably skilled at detecting the visual cues in the images indicating the presence of contraband, and generally knows how to pose the subjects for effective imaging, b) the operator viewing the images has sufficient time (~ 10-20 sec) to study the images, c) the operator makes use of the standard set of image enhancement tools available on the system, and d) contraband items are worn on the surface of the body, not within body cavities or enclosed by tissue. Under these conditions, the BodySearch system has been found capable of detecting metallic (high-Z) threats down to a resolution of 28 AWG, making small blades, bullets, pins, and hypodermic needles detectable. Further, for organic (low-Z) threats of reasonable density (>0.7 g/cc), the BodySearch system is capable of detecting from sub-10gm quantities under ideal conditions to approximately 60gm quantities under the toughest conditions.

Montana State Prison

An AS&E BodySearch system was installed in Montana State Prison in September 1997, to be used to screen inmates returning to the prison from a work release program. Since the installation, the system has reliably taken over 350,000 scans, with only routine maintenance. The prison had a problem with the inmates bringing contraband back into the prison, and had considered requiring each inmate to change clothes upon returning. The expense for starting this program was estimated to be about $200,000, with additional operating costs. The BodySearch system has proven to be a significant deterrent, with a substantial reduction in the quantity of contraband being smuggled into the prison. The system is an alternative to the previously used method of 100% pat search plus random strip search. The BodySearch system is used to scan two inmates simultaneously, with a front and back scan of the two inmates being completed in about 30 seconds. Over 400 inmates are screened each day at the prison. Both inmates and guards prefer the BodySearch system because it is faster and more effective, and because it is less intrusive to both the inmates and prison guards. The BodySearch system has such low levels of radiation that the U.S. Food and Drug Administration has to date placed no restrictions on its use.

In the prison environment, drug interdiction is an objective, but so too is the search and seizure of weapons or materials from which weapons can be fashioned, which includes both metals and plastics. With such a diverse set of interdiction needs, the equipment that is currently used to supplement manual searches, namely metal detectors, fails to provide the operator with comprehensive and specific information about the threat materials being carried. For example, metal detectors cannot distinguish normal metal objects such as zippers in clothing from threats such as metallic weapons. In addition, the need to detect non-metallic objects such as plastics, explosives, and drugs disqualifies the metal detector as a comprehensive deterrent. The BodySearch system was designed specifically to provide detection of all of these materials, sensing not only the presence of objects but providing images of both metallic and non-metallic objects on the body. These images can be used by the operator to locate concealed items and quickly differentiate between normal non-threat items and contraband.

System Upgrades

There are a number of system improvements that can be made to the BodySearch system in order to make it faster, smaller, and more effective at finding contraband concealed on the body.

A) Scan speed

The AS&E BodySearch system is able to make a complete scan of a 6' 10" person in about 10 seconds, with a 10 second delay as the system repositions the x-ray source for the next scan. Currently, the system is only able to scan an image as the x-ray source is descending, due to system limitations. With a few relatively minor modifications, however, the system would be able to acquire an image when the source is both ascending and descending. Assuming that both front and back scans are taken, this would double the system throughput from about 90 people an hour, to 180 people an hour (neglecting delays due to re-positioning subjects).

B) System Footprint

With some re-engineering of the BodySearch system, a major reduction in the overall size, weight, and footprint of the system will be achievable. The weight can be reduced by approximately 2000 lbs, with a 50% reduction in the footprint. A concept illustration (drawn to scale) of the second-generation AS&E BodySearch system is shown next to the current system in Figure 4.

C) Detection Capability and X-ray Energy

The image quality of an x-ray backscatter system is dependent on the number of detected backscatter x-rays per image pixel. This is a function of both the dwell time of the beam at each pixel (scan speed), and the number of x-rays in the incident beam. The number of x-rays increases rapidly with the operating voltage (or end-point energy) of the x-ray tube. As the mean energy of the x-rays increases, however, the x-rays become more penetrating and the scatter image becomes less sensitive to surface objects. The difference in the strength of the backscatter signal from human tissue and from a given item placed against the tissue is called the "backscatter contrast" for that item. Computer simulations have shown that the contrast increases significantly at lower x-ray tube voltages for plastic items, increasing from about 9% at 120kV to 21% at 50kV for 1cm thick polyethylene. It was also found from the simulations that the backscatter contrast decreases as the fat content of the tissue increases.

For drugs and explosives, the contrast is insensitive to the x-ray tube voltage, remaining at about 5% for drugs (1cm thick with density of 0.7 g/cc) and about 8% for explosives (1cm thick PETN). At lower energies, however, the edges of these

Items will become more visible due to the enhanced shadowing effect described previously. For this reason, it would be advantageous to lower the x-ray tube operating voltage. In order not to degrade the image quality, the number of incident x-rays per pixel should be kept at the same level. This can be done by increasing the scan time, or alternately, the power of the x-ray tube power supply can be increased by increasing the anode current as the x-ray tube voltage is lowered.

Lowering the x-ray energy and increasing the anode current, however, results in a larger dose to the person being scanned. The left axis of Figure 5 shows the anode current that must be used to produce the same x-ray flux as the AS&E system operating at 110kV and 4mA. For example, a system operating at 60kV should have an anode current of about 16mA. The right axis (which is a logarithmic scale) shows the absorbed dose per scan for each tube voltage/anode current combination. It can be seen that the dose increases from 5 μrem per scan for 110kV and 4mA, to about 12 μrem per scan at 60kV and 16mA.

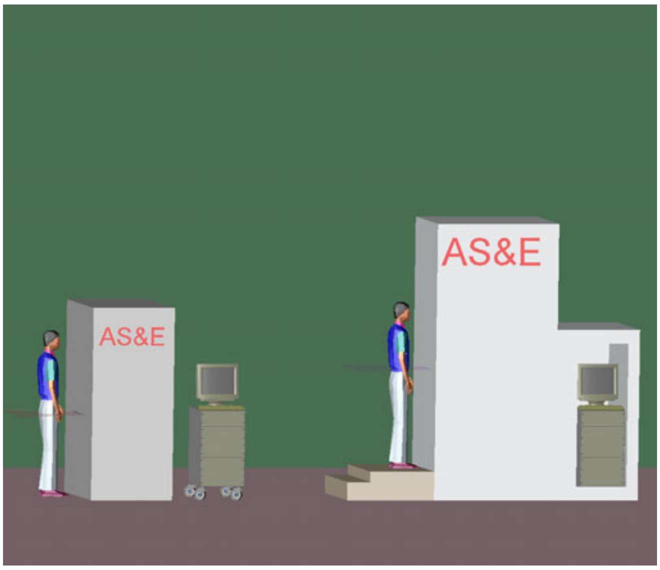

Figure 4 The second-generation AS&E BodySearch system (left) has a greatly reduced footprint and twice the throughput of the current system (right).

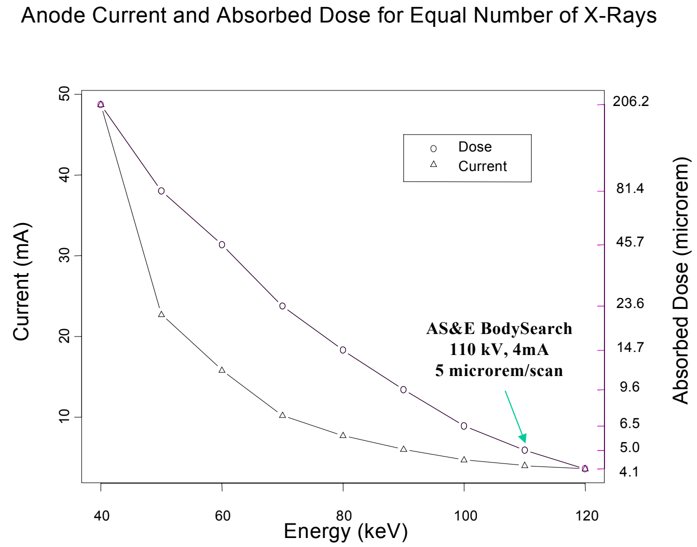

Figure 5 The absorbed dose as a function of x-ray tube voltage and anode current. The left axis shows the anode current required at each tube voltage to produce the same x-ray flux as the AS&E BodySearch system. The right axis shows the absorbed dose for each tube voltage when the system is operated at the anode current indicated by the left axis.

Other Applications of BodySearch

BodySearch is an example of a one-sided x-ray inspection system that is able to create backscatter images, but not transmission images. This technology can potentially be used for many applications where there is no access to the far side of the object. One application that is being studied at AS&E is to use a modified BodySearch system to create scatter images of objects concealed in walls, such as weapons, drugs, currency, or explosives. This application could also be very useful in a prison environment.

Another application is to mount a smaller system on a robot for use by bomb disposal experts. For example, a suspicious bag left against a wall could be scanned by the system, even thought it could not be imaged by an ordinary x-ray transmission system

Summary

The AS&E BodySearch system has proven to be very effective in assisting security personnel to detect concealed weapons, explosives, drugs, and other illegal contraband. The system subjects the person being scanned to an extremely low radiation dose of only 5 μrem. This corresponds to less than 1% of the daily dose from the natural background, and is less than the radiation received from eating a single banana.

With some re-engineering, the overall size, weight, and footprint of the system can be substantially reduced, and the throughput of the system can be increased by at least a factor of two. By operating the x-ray tube at a lower voltage and higher anode current, the ability to detect low-contrast organic materials such as drugs concealed on the body will be enhanced. This will, however, increase the radiation dose received by the person being scanned if the image quality is kept at the same level as the current system.

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The Use of Transmission – Based Technology in the Detection of Clandestine Entrants

Mr Keith Rogers

Deputy Director,Head of Seaport and Channel Tunnel Operations, Dover, United Kingdom.

1. Illegal immigration is an international and European problem, which we can only solve through close co-operation with other countries. For this reason, the UK co-operates both within the framework of the EU as well as bilaterally to solve the problem of illegal immigration. We are working particularly closely with the French authorities to find a solution to cross-Channel illegal immigration. Between 1999 and 2001, the total number of clandestine entrants in the South East district increased significantly, from 9910 in 1999 to 13527 in 2000 and 14,588 in 2001.

2. Methods of clandestine entry include deep concealment within vehicles, breaching the perimeter fencing at the Coquelles site and boarding freight shuttles and penetrating the fencing at Frethun rail depot and boarding rail shuttles.

3. The weight of vehicle movements through Dover and the Channel Tunnel operations in Kent pose a problem for operators and the Immigration Service in searching high volumes of car and freight traffic to detect and deter clandestine entry. There have been many initiatives introduced to reduce the number of clandestine entrants including the introduction of Civil Penalty in April 2000, which was introduced to encourage drivers and operators to make effective checks and improve security. Following the implementation of the Civil Penalty there was a downward trend in the number of clandestine entrants detected and processed in the South East (March 2000 figures were 1,428 compared to 856 in August 2000) Figures began to rise again in the latter months of the year due, it is believed, to be largely increased pressures and the determination by racketeers in France to secure clandestine entry. Civil Penalty and other initiatives such as the checking of vehicles by P&O Stena in Calais and positive action by the PAF have helped reduce the overall clandestine entry through Kent by 15% between 2000 and 2001. Although these initiatives have contributed to a decrease in the number of clandestine entrants there were still 7,292 clandestine entrants encountered between January and July 2002. To date in 2002 the number clandestine entrants show a further 5 % decrease on the same period in 2001, taking into account sea and channel tunnel penetration.

4. Clandestines are continuing to enter the UK illegally by hiding in lorries, the concealment is becoming more organised with evidence of specially modified vehicles, including pipes to release carbon dioxide, to evade detection. Deep concealment increases the risks to migrants themselves and further risks of accident whatever the form of transport. The risk that migrants face was unfortunately highlighted with the tragedy in June 2000 when 58 Chinese nationals were discovered dead in the back of a refrigerated lorry. Only two of the 60 clandestines survived, the others died from suffocation after the only air vent on the side of the lorry was closed.

5. There have been several reported incidents where the concealment of migrants could have resulted in fatalities, for example:

On 12 April 2001 at Coquelles French Customs intercepted a 7.5m truck laden with rags and fabric, amongst which were 24 Indian nationals. They were reportedly close to asphyxiation having been in the lorry for several hours.
6 January 2000 at Dover Immigration Officers examined a refrigerated load of frozen chicken whereupon they discovered nine illegals, wrapped in thermals, sitting upon the load. The unit was chilled to –9 degrees C. and there was no way of exiting the vehicle, which had solid sides.
On 3 June 2000 on the M20 at Maidstone in Kent, a 7.5 metre van driven by two Portuguese nationals was stopped and three Lithuanian females were found concealed in the back. They were taken to hospital suffering from the heat and lack of oxygen.

6. The use of transmission-based technology is highly effective in confirming the presence or otherwise of concealed persons and also has the preventative role of ensuring that the deep concealment of migrants does not result in fatalities. The scanners are used as a layered approach to searches alongside other technologies, including CO2 sensors, heartbeat detectors and millimetric wave technologies. Heartbeat detectors are now in operation following a successful trial. In addition, the Immigration Service is likely to buy millimetric wave technology as part of this layered detection screen.

7. Since October 2001, the Immigration Service has been co-using HM Customs and Excise scanners in Dover Eastern Docks. The first Immigration Service scanner became operational at the end of June 2002. Discussions with the French are ongoing concerning the use of the scanners on French territory. Current legislation prevents the use of scanners in France for the detection of people using x-ray. Discussions are also underway with the Belgian authorities for the use of scanners in Zeebrugge, early indications are favourable, their use does not appear to be contrary to Health and Safety procedures and there do not appear to be any legislative difficulties. For the UK the Home Secretary decided, on 18 September 2001, that there was a clear justification for using transmission based technology following his consultation process that ended on 31 August 2001 and under the terms of EU Directive 96/29(1).

8. Before the scanner is deployed steps are taken to ensure that the possibility of being affected by ionising radiation is kept to an absolute minimum by: ensuring the driver leaves the vehicle, verifying that there are no other people within the vehicle and finally a warning announcement is made, in several different languages, that the scanner is about to commence and thus giving the clandestine the opportunity to bring their concealment to the officer's attention.

9. The use of scanners is part of wide range of initiatives used to deter clandestine entry and they are only used following strict guidelines to prevent both clandestine entrants and the operators of the scanner from being affected by ionising radiation. Mr Adam Ross*, our Radiation Protection Advisor, will offer you more detail.

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`X-ray Control at Countries' Borders

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Summary

At the borders between states X-rays and gamma rays are use to control goods and persons. Caesium 137, Cobalt 60 and accelerators (5 and 10MeV) produce the radiation. Main objects are drogues, explosives, arms, cigarettes and humans. Transparency images and/or images and analyses of forward and backward radiation are used. After the reunification of Germany it became known that the MfS had controlled cars and lorries by fluoroscopy at the inner German border exposing drivers and passengers. Furthermore the MfS used radioactive substances to pursuit persons, letters, manuscripts and foreign money. The Securitate, the secret service of Romania killed several persons by Thallium 40.

X-rays and gamma rays are used at the borders between states to detect
· Drugs for addiction
· Explosives
· Weapons
· Cigarettes
· Human beings
· Other items

The images are produced by different techniques: In general fluoroscopy with stationary or mobile x-ray tubes or with permanent radiation sources like Caesium 137 or Cobalt 60 is being applied. A radiographic image is created by the penetrating radiation, which shows the object in superimposition. Computed tomography (CT) serves for control of luggage; it produces a digital image without superimposition. Identification of chemical components is possible by means of scatter radiation (Lotz 2002, Eisenfeld et al 2000, Halter 1994).

Radioactive substances are used to mark people, manuscripts and other items; they are applied to facilitate pursuit or to identify the ways of transport. In special case radioactive substances are also used to slowly kill "without" evidence (Lotz 2002, Eisenfeld et al 2000, Halter 1994).

Drugs

Drugs are being transported in the body of special human carries. In general the material is filled into condoms, which are then swallowed. This tiered package in the GI-tract is usually easily visible on radiographs. The French and the Spanish terminology, "sign of the condom," describe the characteristic finding. Smaller items can be transported sutured underneath the skin. This is also valid for small stolen items like jewels and other precious stones. They can also be transported in any natural opening of the body, of course.

Drugs in large quantities may be transported as bulk-type merchandise hidden in other materials. False declarations in the papers of sealed containers are common. The increase in the international traffic has induced the necessity to control goods directly at the borders or ports of entry. Spot checks are obligatory, at least. This must be done quickly to avoid blocking the traffic. This control is performed by fluoroscopy units that work either with accelerators (5MeV and 10MeV) or with permanent radiation (Caesium 137 or Cobalt 60).

One can make a difference between direct and indirect signs in looking for contraband: The direct sign proves the drug or makes it highly probable. Indirect signs are suspicious clues. An example is an unusual cavity in a container behind other goods and therefore difficult to inspect. An opaque petrol tank of an old-timer transported in a Container raises suspicion. This is an indirect sign for drugs. Another hint towards drug transport is the fact that the old-timer comes from South America and is transported to Europe in a container, which is even sealed.

Radiation-accelerators are more expensive than units with permanent radiation emitters. They work with high energy that penetrates containers and railway carriages easily. Therefore, many objects can be controlled in rapid succession. In general they work in biplane fashion.

Units with Caesium 137 and Cobalt 60 often work with fluoroscopy in one plane only. The radiation source is often movable, the detector is fixed. Therefore an oblique projection is possible. Such units are constructed in and sold by China.

The unit in the port of Hamburg has special features, which prevent the direct radiation exposure of people. Containers that are declared to contain food are excluded from control, because the exposure of food by x-rays or gamma rays is not allowed in Germany. The reason is the concept that ionising radiation creates ions and radicals in the food; they may react with proteins of the body when digested with adverse effects.

The pamphlets and other descriptions of the non-European manufacturers as well as their videos in the Internet indicate that they don't bother to prevent direct radiation exposure of human beings during passage through the radiation beam. The driver of a truck, for instance, and also his passengers may be exposed. Furthermore the exposure of the equipment-operator is not discussed. By the way, some units with Caesium 137 and Cobalt 60 are quite mobile. They can be disassembled and reassembled in 1 to 2 days.

Humans

Sealed containers are often used to transport people illegally. Disastrous outcomes with a high number of persons suffocated are known from the channel ports of Great Britain. Transport of people in containers is also known at the US-Mexican border. There are different methods for their detection in sealed containers. One is the measurement of carbon dioxide inside, the container usually sealed airtight. Detection of people by fluoroscopy is also possible. Such pictures have been from the US-Mexican border in German papers and periodicals (AS&E 2000, Séché 2001).

Explosives

On December 22nd, 2001 the British citizen Richard Reed, during plane ride, tried to set fire to ten ounces of C4 hidden in his shoes. C4 belongs to the RDE (Rapid Detonation Explosives), which form a group of special explosives used for military purpose all over the world. One famous name that is associated with this group of substances is "Semtex", which contains C4. The name is a combination of the first syllabi of Semtin and Explosives. Semtin is a village near the factory in former Czechoslovakia where these explosives were produced. C4 is a paste, which can easily be modelled into a Butterfly (fig. 1) and thus transported without raising suspicion. 300g of Semtex placed in a radio were the reason for the planecrash of Lockerbee. Richard Reed tried to produce an explosion near the outer wall; therefore he tried to set fire sitting in the cabin. An explosion in the toilets, i.e. in the centre of the plan, could have left the outer wall intact; the walls of the toilets and the distance to the outer wall would have mitigated the explosion.

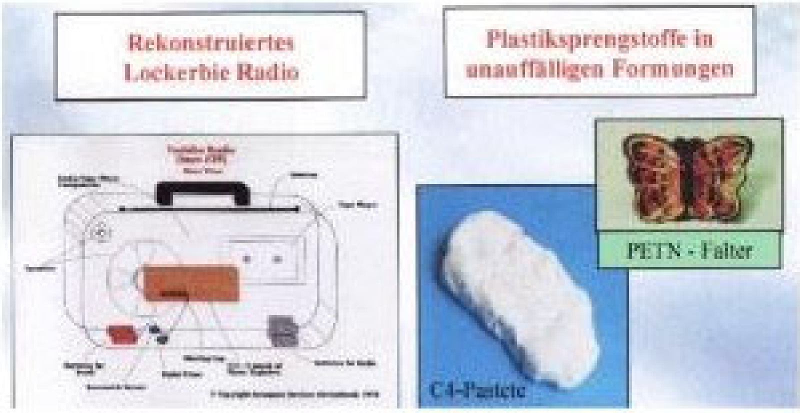

Fig. 1: Lockerbee, reconstruction of the radio that contained the explosives. C4 in form of a paste, PETN in form of a butterfly. Yxlon 2002.

In order to identify explosives on a fluoroscopic picture, one has to rely on indirect signs. If a packet of plastic is detected in a radio, a control by inspection is mandatory, since this is unusual and a potential clue for explosives. Circuitry like wires and electric equipment in untypical locations could be another indirect sign. One has to consider the possibility that it may serve for ignition; and in case of doubt inspection is obligatory.

The direct proof of explosives like Semtex, C4 and TNT is possible by scatter radiation (fig. 2), done by an analysis of scattered gamma radiation in special detectors. A precise collimation allows identification of the source and also its localisation, if one knows the path of the primary beam. In personal luggage or in any other transported items, for that matter, it is possible to identify chemicals without having to open the luggage. The combination with fluoroscopy can provide additional information. At least it is thus possible to differentiate items that are of low and equal density and thus poorly detectable - let alone discernible - by fluoroscopy alone.

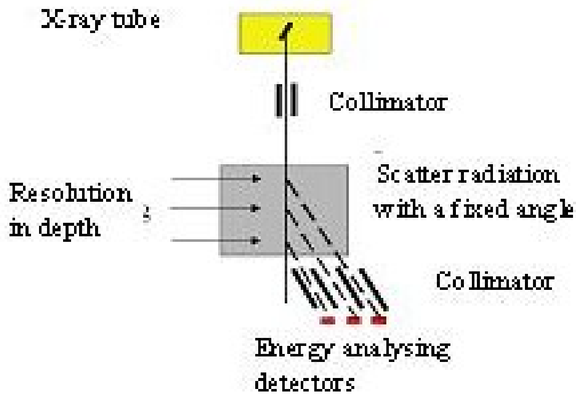

Fig. 2: X-ray scatter image. Principle of analysis.

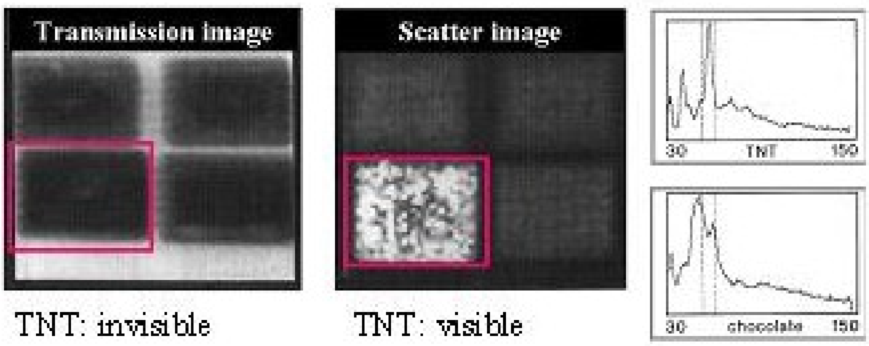

Figure 3: Basket with four packets, one packet containing TNT and three with chocolate. Fluoroscopy shows no difference in form and density, it just allows localising the items. The scatter image shows the difference. The analysis of the scatter radiation allows identification of the substance. The giveaway is the spectrum of TNT vs. that of chocolate.

Weapons

Weapons hidden in containers or in luggage and other transport media may be found by fluoroscopy of containers, cars, railroad cars. Weapons carried on the surface of the body hidden underneath the clothing need a different approach. For their detection, industry has developed surface scanners that work with backscatter radiation. Weapons become visible when they contain metal. The x-ray exposure of the examined person is estimated to be 0.05µSv/scan. With two scans, one from each side, this means 0.1µSv. For the equipment's operator the manufacturer claims a dose of 5µSv/h, only. This can be compared with the natural exposure by cosmic radiation during a flight. Passengers and crewmembers receive some 5 to 7µSv per hour. Surface scans are said to be used for controlling passengers at

international air ports in Europe (Frankfurt) and in Great Britain without the passengers' knowledge - let alone consent about this radiation exposure.
So far, I have not had an opportunity to verify this information. It is probable that surface scanners are used to control the access either to important buildings or to important people in Africa and Asia without the knowledge of the visitor.

Cigarettes and alcoholic beverages
Cigarettes and alcohol are being smuggled in containers in outright wholesale amounts. A favourite place to hide cigarettes is in the wall of a container. One can observe the combination of quantities of cigarettes with other goods of similar appearance for deceptive purpose. Alcohol as a liquid has to be transported in tanks. If a liquid substance is found in tanks in a container that should not contain fluids and its presence is not properly explained, alcohol is always suspected. The movements of the fluid level allow recognising liquid while the container is being processed through the control unit.

Wolke 005 (Cloud 005)
Wolke 005 is concerned with:
· The use of radioactive substances for physical injury (because proof and identification of the substance would be difficult).
· The control of cars and trucks at the border between East and West Germany by fluoroscopy (without knowledge of drivers and passengers).
· The tracing of persons, manuscripts, documents, money, cars and other objects by radioactive markers.

This project came to light after the fall of the Berlin wall; its name was meant to associate with James Bond 007. It was initiated by the MfS (Ministerium für Staatssicherheit, Stasi) and was kept secret. It was carried out by service units of line 26 (Diensteinheiten der "Linie 26"). The MfS had cooperated with the "Central Institute for Nuclear Research" (Zentralinstitut für Kernforschung), which delivered the radiation sources for fluoroscopy and the radioactive substances for tracing. The beginning was an expertise named "TOXDAT" which evaluated the possibilities to be kept secret intended (or accepted) damage by radiation. The available documents have been analysed by the "Gauckbehörde" (established to collect and analyse East-German crimes). In the mean time the German Ministry of Health and the Ministry of Ecology have estimated the doses applied.

Persons
Persons were marked by placing needles with radioactive substances into their clothing or their shoes.

These substances emitted gamma rays of high energy. Therefore the tracing of a target was possible even from a great distance. A special detector indicating radiation by vibration was carried under the jacket of the pursuer of the victim.

Papers, documents, manuscripts, foreign money
Substances like Carbon 14, Tritium and Sodium 24 were employed. The use of Carbon 14 and Tritium resulted only in surface measurements on letters or other papers. Sodium 24, however, has a half time of 15 hours and a penetrating gamma radiation, which permitted the detection and pursuit from a larger distance.

The radiation risk was hardly considered.

· In 1985 a theft of West German currency (DM) was investigated. Among the suspects they even included a woman with known pregnancy.

· In 1988 twenty 5 DM paper-notes were marked with 60µCi in order to identify the persons who held the money, which was illegal. The radiation doses to a carrier would have been 2 Sv, if one 5 DM paper-note was carried on the body continuously for three months. Interestingly enough twelve 5 DM paper-notes still remain undetected.

Cars, Tyres, Plates

Cars tyres and license plates were marked. With an air gun a small lead projectile was fired onto the tyre from a distance of up to 25m. The projectile had an aluminium marker, which contained a silver wire with Ag110m. The emitted penetrating radiation allowed tracking from a distance.

Fluoroscopy of vehicles at the inner German border

The majority of the inner German border control-stations had been equipped with units for fluoroscopy of cars and trucks. Caesium 137 was the radiation source. Without their knowledge the drivers and the passengers of car or truck were irradiated. They were advised to drive via the passage were the unit was installed. A hidden human body could be recognised by the typical absorption seen on the control screen and thus induce further investigation. There is an interesting discussion how differently the amount of radiation per passage was estimated by the various people involved (probably influenced by location and time of application: Originally the MfS/Stasi had estimated the doses per passage up to 1.000nSv. The equipment constructor argued (after 1990) with a dose of 15nSv/passage; finally the court ruled the dose was 50nSv/passage!

Killing by radiation, Securitate in the 50s

After the death of Ceausescu, secret actions of the Securitate, the secret service of Romania became known: The agent Nikolai Khoklov was killed by Thallium 42 (b: 3.8 MeV, g: 1.5 MeV, T/2: 12h). Furthermore, the former foreign minister Kiraly was killed with the same substance. The application was performed by injection with a needle hidden in an umbrella. Comparable actions were performed by injecting ricin, a strong poison.

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Detection of Weapons

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Abstract

There are both non-ionizing and ionizing radiation-producing devices which can be used to detect weapons, and the determination of the device used depends to some extent on the weapon sought. However, the definition of "weapon" has expanded since the events of 11 September 2001 to include chemical, biological and nuclear weapons as well as conventional guns and knives. In the United States (US), regulation of devices for weapons detection is divided between the federal government and the governments of the 50 States. The States have an avenue for expressing their opinions, and it is through the Conference of Radiation Control Program Directors meetings, where resolutions are proposed, discussed and voted upon by all of the States.

Detection of Weapons: What, Where, How

Our world has been changed by the events of the 11 September 2001 terrorist attack on the World Trade Center. No longer are we merely concerned with contraband such as firearms or edged weapons which are readily detectable through metal detectors. We are also concerned with weapons of mass destruction such as chemical, biological, and nuclear weapons. Those of us in the radiological protection field are especially concerned with the possibility of "dirty bombs" or radioactive materials that could be dispersed using conventional explosives. There is also an insidious threat of the dispersion of radioactive materials in a "stealth" scenario, where materials would be placed in a crowded area (a shopping mall, for instance) where detection might not be immediate.

This means that the definition of "weapons" (or other contraband) has changed, and that results in changing technology for detection devices, which leads to a changing regulatory structure. Traditional detection technology (metal detectors) for weapons had long been in place throughout the United States at prisons, courthouses, and some inner city schools, where gangs were prevalent. U.S. Customs provided screening at ports and other border crossings. Routine searches of persons at an international border are not subject to any requirement of reasonable suspicion, probable cause, or warrant. Automobile travellers may be stopped at fixed checkpoints, and searched, even if the stop is based largely on ethnicity. Boats on inland waters with ready access to the sea may be hailed and boarded with no suspicion whatever.

But until 11 September, passengers at airline terminals were not routinely checked for weapons. Passengers entering the U.S. could be detained under suspicion of smuggling narcotics in their alimentary canal, and given a choice of being detained until they produced a monitored bowel movement, being x-rayed, or returning to the country of origin on the next available flight. However, the individual would receive the diagnostic x-ray by a licensed radiologic technologist under a physician's orders. The radiologist that serves as the Chair of the New Jersey Commission on Radiation Protection said he would not hesitate to order the x-ray since rupture of a packet of drugs could be fatal.

There were other changes as well. For example, all government buildings improved their security. Nuclear power plant security was enhanced by most U.S. Governors, who stationed National Guard troops there. The Winter 2002 Olympic Games in Salt Lake City, Utah, had stringent security. After the episode of mail being contaminated with anthrax, post offices considered installing irradiators to ensure that any further anthrax contamination would be eliminated.

Traditional metal detectors do not use ionizing radiation. However, the backscatter x-ray detection system that can identify guns and knives, as well as explosives and narcotics concealed outside the body, may lead to changes in the types of detection in common use. These "people scanners" or "personnel security screening devices" operate by the principle of backscatter and exposure is on the order of 0.1 – 0.2 microSv per scan. Regular x-ray techniques are still used if an individual is suspected of carrying contraband internally. However, the x-ray procedures must be ordered by a physician, and carried out in a medical facility.

U.S. Customs has used large x-ray or radioactive material sources such as Cobalt-60 for the detection of contraband in tractor-trailers. These large machines can accommodate containerized freight, but if people are hiding in the container, they will be exposed to ionizing radiation unintentionally. U.S. Customs officials and other police department personnel are now being equipped with small neutron detection devices. These were used by the New York City police department during the most recent New Year's Eve celebration at Times Square, for instance.

Chemical and biological sensors are also available. For example, dogs are trained to sniff out explosives, and this detection technique results in no adverse health impact to the individuals being monitored.

Radiological Detection: Who and Why

In medical diagnostic x-ray procedures, the person who is receiving the risk from the x-ray exposure is the same as the person who is getting the benefit from the x-ray exposure. In other words, the person getting the diagnostic benefit is the one bearing the radiation risk. By contrast, when screening to detect weapons, the person receiving the screen (by ionizing or non-ionizing radiation) bears the risk. However, it is the population at large that is receiving the benefit. Of course, the individual traveller does benefit from having fellow passengers screened, thereby identifying the terrorist traveller.

In using an x-ray screening device at the entrance to a prison, scanning prisoners protects the prison guards from assault with a smuggled weapon. Prisoners are assumed to have restricted rights. However, in scanning all visitors to prisons to search for contraband, the individuals are giving up their rights to privacy in order to visit their friends or family in prison. It is common practice for women visiting their husbands to bring their children, and the children are scanned as well.

In some cases, the prison guards have the authority to choose who they will subject to a search. They may use profiling - or determining those that are likely to be smuggling contraband by virtue of their race, ethnic background, demeanour, appearance, or other defining characteristics. Are low income, low socio-economic status individuals more likely to be subjected to searches? Probably.

Schools where weapons detection devices have been installed are more likely to be in the poor neighbourhoods, where gangs are prevalent. In the U.S., these are issues of "environmental justice," that is whether those people who are already exposed to a number of environmental pollutants are also subject to additional exposure from weapons screening. While no one is questioning the importance of keeping guns and knives out of schools, the question is whether a non-ionizing device can be a suitable alternative for weapons screening to a backscatter x-ray device, despite the low level of exposure per scan.

Regulation of Devices for the Detection of Contraband: Role of U.S. Federal Government

Regulation of "medical devices" is the purview of the US Food and Drug Administration (FDA), Center for Devices and Radiological Health, a federal agency. Under the law, personnel security screening systems are not "medical devices" and therefore, do not need FDA clearance before they can be marketed. However, manufacturers of any electronic products that emit x-rays are required to submit a report to FDA before they can market the product. The report describes the operational characteristics of the product that can affect radiation exposure.

The FDA has an advisory committee, the Technical Electronic Product Radiation Safety Standards Committee (TEPRSSC) that provides advice to the agency on regulatory issues. The "people scanner" was first brought to the attention of TEPPRSC in April 1997. At that time, TEPRSSC advised the FDA to write a standard for backscatter detection devices, because the members were concerned that the images produced were not very good. They felt that if the radiation exposure was increased, the images would improve, and the detection capability for contraband would improve. However, they thought that if the devices proliferated throughout society, a single individual could be exposed multiple times a day if they were scanned at the entrance to governmental buildings, schools, airline terminals, prisons, post offices, etc. The collective population dose was also of concern. The FDA does not currently have mandatory standards, but the N43 Committee of the American National Standards Institute (ANSI) has drafted a consensus standard. FDA will base their regulations on the ANSI standard.

Regulation of Devices for the Detection of Contraband: Role of U.S. State Government

While the federal government has authority to set standards for new devices, the 50 States have the authority to regulate those devices in use. States can be more stringent, and can also ban the use of certain devices. However, states do not have authority over facilities under the jurisdiction of federal agency properties, and hence, cannot regulate x-ray scanners at Customs installations. Some might consider this a loophole.

Additionally, the States dictate their own priorities. In a State with a number of uranium mines and mill tailings, a laboratory to analyze environmental samples may be the highest priority. In a State with a large population of retired individuals, a greater emphasis may be placed on medical facility regulation due to the higher patient population. A State with a high occurrence of radon may place greater emphasis on building codes for radon-resistant new construction. However, regulations for low-dose devices such as backscatter x-ray scanners may not warrant a great deal of priority for rulemaking by any one State.

The Conference of Radiation Control Program Directors, Inc. (CRCPD) is an organization comprised of representatives from the radiation control programs of the states. The CRCPD provides a forum for centralized communication on radiological protection matters between the States and the federal government, and among the individual States. In May 1999, the CRCPD passed a resolution (Figure 1) relating to the public being irradiated with ionizing radiation for non-medical purposes. The resolution was controversial, and engendered a significant amount of discussion.

In one State (Washington), people scanners were in place at a prison, and all prisoners and their visitors were subject to scanning. At another prison in California, visitors were given a choice of the people scanner (clearly marked that x-rays were produced) or a physical search. No real risk communication was employed. The individuals had no idea if the x-ray was in the Sievert, millisievert, or microsievert range, nor did they understand the relationship with natural background radiation.

Also discussed by the CRCPD was the training of the guards who were operating the people scanners. Training was about 1 hour, and guards practiced by scanning each other. However, no mention was made about training in the resolution because the group decided that it was a stronger resolution to simply eliminate this use of x-rays.

A great deal of discussion surrounded the issue of dose. With the dose from a single scan on the order of 0.1 microSv, the question arose about whether the linear non-threshold hypothesis even extends to that range and the resulting affects on the risk. However, the principle of "as low as reasonably achievable" or ALARA would dictate that if alternatives are available to eliminate dose, even if low, the alternatives should be pursued. Risk discussion also centered on the risk to the entire population - from repeated scanning if backscatter devices were placed in many public places. However, risk from the extremely low dose, fractionated from each location, is difficult to extrapolate.

The CRCPD resolution called for the immediate discontinuance of this use of x-ray screening. The resolution did allow the practice if an alternative means for weapons detection did not exist. The resolution did allow States to look to international guidance on the practice. The most important part of any resolution is to convey to other agencies the consensus opinion of the states, so the letter to the U.S. Customs Service and other appropriate federal agencies is essential in communicating the state position. The resolution was reviewed at the CRCPD meeting in May 2002. The majority of the States present still agreed with the resolution as written, so there were no changes made, even after experiencing the events of 11 September.

Electromagnetic Field (EMF) Interference

In 1998, the FDA issued a safety notification that the operation of certain medical devices, including pacemakers, defibrillators, and spinal cord stimulators may be affected by the electromagnetic fields produced by anti-theft systems and metal detectors. While the number of reported patient injuries was low, the notification went to cardiologists, neurologists and emergency physicians to help them to advise patients with these devices.

The European Society of Cardiology issued a similar statement. The advice to patients was:

O Be aware that these systems may be hidden in entrances or exits where they are not readily visible in many commercial establishments.

O Do not stay near the system or metal detector longer than is necessary and do not lean against the system.

O If scanning with a hand held metal detector is necessary, warn the security personnel that you have an electronic medical device. You may wish to ask for an alternate form of personal search.

After the FDA's safety notification, medical device manufacturers and metal detection manufacturers did meet and exchange information to try to preclude newly manufactured medical devices from being subject to the EMF interference.

Detection of Biological Weapons

While the title of the paper is "Detection of Weapons," it is important to note that radiological devices have been used in the destruction of biological weapons. Since the U.S. Mail was used to disseminate anthrax spores, the Postal Service had to quickly come up with a way to decontaminate large quantities of mail that may have been exposed to the anthrax. They contracted with two large irradiation firms to irradiate the mail, one of which was an accelerator located in New Jersey. A 10 MeV electron beam shot was used to expose the mail as it moved along on a conveyor belt. The mail had to be irradiated from both sides in case there was some shielding material in the mail. Things like CD-ROMs, or coins sent to the U.S. President from school students, or other high Z materials could shield or scatter radiation causing areas of high dose and areas of low dose. The dose to kill the anthrax spores was 56 kiloGray dose (or 5.6 megaRads). By irradiating the mail from both sides, the dose was close to 12 megaRads. Since all of the mail that was possibly contaminated was irradiated, some film badges were invalidated. The irradiation heated the mail to about 140 to 160 degrees Fahrenheit. In fact, there was at least one fire that occurred in the facility in New Jersey. Each piece of mail that was treated by irradiation was placed in a plastic bag that explained to the receiver that the mail itself did not become radioactive through treatment - only biological agents were killed. While mail irradiation has not become common practice, at least some mail sent to U.S. government offices continues to be irradiated.

"Dirty Bombs"

Where would a terrorist look for the raw materials for a dirty bomb? The first concern of many citizens is what they perceive as a vulnerability - shipments of spent fuel. Since the U.S. does not have a repository for spent fuel yet, there have been no shipments of commercial nuclear fuel from nuclear power plants. It is stored on the site of each nuclear power plant. However, there are shipments of Highway Route Controlled Quantities (HRCQ) such as Co-60 for irradiation facilities, and the facilities themselves, could be vulnerable to theft of material.

Would a terrorist have better success in obtaining radiological sources by importing the radioactive material from a less secure source in another country or by stealing the radioactive material from a domestic source?

As noted in Figure 2, there are many locations where material for "dirty bombs" might be available. Clearly, the damage from a dirty bomb depends on many factors, but even if the radiological damage is minimal, the psychological damage would be significant. The immediate fatalities would probably be due to the explosion, not the radiological contamination, but the fact that all debris would have to be handled as potentially contaminated would make clean-up difficult. The contamination could reach large areas, but may be only low-level. The difficulty will be in convincing people that it is permissible to return to their home or business. They will be suspicious of the clean-up and any level above background may be unacceptable to them. This has led many to describe dirty bombs as "weapons of mass disturbance."

Much can be learned from response to incidents of accidental contamination. From the incident in Goiania, many people feared contamination and damage to their health - they feared they had contracted incurable and fatal diseases. Some of the inhabitants of Goiania were discriminated against, even by their relatives. Sales of cattle, grain, and other agricultural products, of cloth and cotton products fell by 25% after the accident.

New Jersey Capability: Planning and Incident Response
In New Jersey, we have not changed our response structure to prepare for the dirty bomb scenario. Our regular radioactive materials inspectors serve on our response teams. They are equipped with portable gamma spectrometry equipment to help them to identify unknown radioactive materials. Their equipment kit consists of detectors with different sensitivities and the ability to detect alpha, beta, gamma or some combination of those emissions. The staff members are familiar with the facilities in New Jersey which use radioactive materials, the radionuclides which would be available to a terrorist, and the appropriate instrumentation for detection.Our state is one of the smaller states in the U.S., but it is a corridor for transport. Ports, airports, railways, and highways make our state an important transportation "hub," or center. For instance, Federal Express has a hub in the city of Newark, New Jersey.

We also have a number of scrap metal recycling facilities. These have all installed radiation detection equipment to prevent their facility from being accidentally contaminated if a radioactive material source were inadvertently placed in the scrap pile. The solid waste incinerators have also installed radiation detection equipment at their gates to prevent contamination of their facilities.

In a small State, with 3% of the US population and 0.2% of the U.S. land mass, we respond to about 80 incidents each year (Figure 3). These responses enable us to maintain our skills in identifying unknown radioactive substances, isolating them, and arranging for proper disposal. Of course, about half of the incidents involve short-lived radioactive materials such as patient waste from nuclear medicine procedures. Although this waste is required to be stored for decay before it is discarded, the instructions are not always followed by incontinent patients.

However, that leaves about half of the incidents to be lost or stolen gauges, scrap metal contamination, or "found" sources. We have responded to radium needles in discarded file cabinets, tritium exit signs dismantled by 16 year-old teenagers who ingested the tritium, and other such unusual events. But we dread the prospect of a response to a dirty bomb incident.

Conclusions and Recommendations
The original topic that was assigned to me was the detection of weapons, and the non-medical use of x-rays in their detection. It was important to demonstrate that there are both non ionizing and ionizing radiation-producing devices which can be used to detect weapons, and that the determination of the device used depends to some extent on the weapon sought. However, the definition of "weapon" has expanded since the events of 11 September 2001 to include chemical, biological and nuclear weapons as well as conventional guns and knives. In the United States, regulation of devices for weapons detection is divided between the federal government and the state government. States have an avenue for expressing their opinions, and it is through the CRCPD meetings, where resolutions are proposed, discussed and voted upon by all of the States.

Regarding the detection of "dirty bombs", preparation for response is necessary, but prevention of an incident is paramount. It is clear that there are significant radiological risks and liabilities associated with radioactive materials sources that do not exist when conventional x-ray or accelerator sources are chosen. The need to provide security for radioactive materials sources against terrorist use is a detriment that should be considered in the justification of a practice. Licensing and regulatory policies should be revised to ensure safety and security.

References

CRCPD Resolution on Irradiation of Public for non-Medical Purposes
http://www.crcpd.org/medicine/medicine_19990599.htm

Food and Drug Administration, Center for Devices and Radiological Health, Technical Electronic Product Radiation Safety and Standards Committee,
http://www.fda.gov./cdrh/teprsc.html

Food and Drug Administration, Information about Anti-Theft and Metal Detector Systems and Pacemakers, ICDs and Spinal Cord Stimulators
http://www.fda.gov/cdrh/safety/easnote.html

Figure 1: CRCPD Resolution (5/12/99)

Relating to: Public being irradiated with ionizing radiation for non-medical purposes.
Whereas: Members of the public are being irradiated with ionizing radiation for non-medical purposes, specifically, members of the public including children, are irradiated at each visit to certain prisons;

Whereas: This results in unnecessary radiation exposure with little or no benefit (medical or otherwise) to those individuals;

Whereas: The practice results in repeated irradiation of many individuals;

Whereas: Federal policy discourages the use of x-ray examinations that are not medically necessary;

Whereas: State and federal agencies have reduced or eliminated unnecessary screening and administrative x-rays;

Now, therefore, be it resolved, the CRCPD membership recommends that screening or administrative procedures requiring human exposure to ionizing radiation for non-medical purposes be immediately discontinued;

Be it further resolved: the CRCPD endorses regulatory or statutory amendments that will preclude this practice except where effective alternative means do not exist;

Be it further resolved: the CRCPD urges each state to adopt regulations pursuant to international guidance that would preclude this practice without adequate assessment and justification accompanied by the methodology for optimization of the equipment and process;

Be it further resolved: the CRCPD submit a letter to the U.S. Customs service and other appropriate federal agencies advising such agencies of our position on this issue.

Figure 2: Locations for radioactive materials in the U.S.

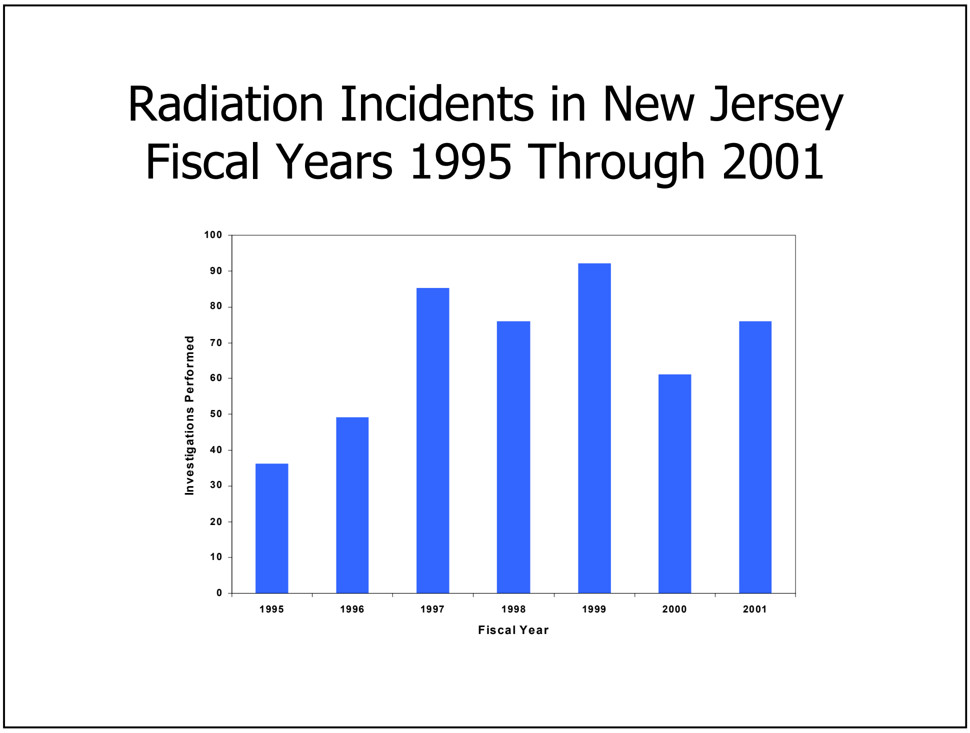
Radioactive Material Licenses:

21,000 locations in the U.S. are licensed to use radioactive materials
101 are nuclear power plants
1000 are irradiators

In the Past 5 years

1500 radioactive sources were lost or stolen
Only 835 were recovered.

Figure 3: Response to Radioactive Materials events in New Jersey



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The Role of X-rays in Drug Detection

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Presentation of the Swedish Customs
One of the tasks of the customs is to supervise and monitor the traffic to and from non-EU countries while ensuring that the EU regulations on the import and export of goods are followed. We carry out many of these tasks on the behalf of other authorities. For example, we collect VAT for the National Taxation Board and are the supervisory body for animals and food for the Swedish Board of Agriculture.

The free movement of goods applies, in principle, to all goods that are transported from or to another country within the EU. It is prohibited to limit the free movement of goods in any way. However, the EU has introduced certain bans and restrictions. These are in the interests of, for example, maintaining public order or protecting the lives and wellbeing of the public and animals.

In Sweden the Customs is responsible for stopping travellers on arrival to Sweden and checking if they are carrying, for example, illicit drugs, firearms and ammunition, animals, or other dangerous goods that are a threat to life, health or the environment of our country. There are also restrictions on how much beer, wine, spirits and tobacco can be brought into Sweden.

We also check that the correct duty and taxes have been paid for goods that are brought into or taken out of Sweden.

Fighting crimes
The combating of drug smuggling, large scale smuggling of alcohol and tobacco products, as well as economic criminality are fields of actions we have given high priority. In order to carry out these crime-fighting tasks as efficiently as possible we are dependent upon help from the public and the business sector and we also co-operate with other public authorities. In addition to that an efficient intelligence service is necessary for success and of course we are also dependent on various technical equipment such as x-rays.

We have x-ray equipment, which we use to scan letters, parcels, suitcases, boxes and also palletised goods. This autumn we will also buy our first equipment for scanning of sea containers and lorries. We have not yet decided if we will buy a mobile or relocatable scanner or whether we will choose equipment with x-ray or gamma source.

Body search
As drug smugglers sometimes hide drugs even in their own body, we need to take other steps in order to reveal the smuggling attempts. One of the tools for this task is the use of x-rays to detect the drugs. In the following the procedures leading to such an examination will be described, both from a legal and a practical point of view.

The customs officers are placed at different border crossing points as for example at airports. There will be no random inspections of people. All selection of travellers for further investigation are based on observations by the customs officer, information from intelligence, a tip-off or other factors that indicate that a traveller has failed to declare goods – such as by not giving the correct information when asked or by choosing the green, blue or red channel.

Anyone can be stopped because a customs officer can challenge a traveller without suspecting a crime. (That is not applicable to intra-EU travellers. To select them, we must have a "reason to believe".) We are also allowed to check the luggage of the traveller. If a crime is suspected then the customs officer is allowed to conduct a body search and even what we in Sweden call superficial body examination, as well as ask for a urine sample.

A **body search** means the examination of clothes and other item persons are wearing on their body and of bags, packages and other objects, which persons have with them. It also means that they sometimes have to take off some of their clothes.

A **superficial body examination** is the examination exterior of the human body. In those cases the suspect is asked to take off all clothes. We are allowed to tell the suspect to lift his arms and to show the soles of his feet and we may also carefully search his hair and beard if necessary**.** Beyond that we are not allowed to ask him to take up a certain position.

In accordance with the customs legislation, customs officers could perform all the actions mentioned so far, without any further authorisation. These actions alone are serious infringements on a person's privacy and might be experienced as very uncomfortable. Customs officers are aware of this and conduct these checks with objectivity and respect and the principle of proportion should always apply. However, if the actions mentioned do not give any results and we still have reason to believe that a traveller is smuggling drugs, there is only one more place to examine and that is <u>in</u> the body.

Body examination

To go further with a body examination, we need to take support from other legislation, which is The Swedish Code of Judicial Procedure. According to that code a person reasonably suspected of a punishable offence for which imprisonment may be imposed may be subjected to a body examination. The purpose is to discover an object subject to seizure or other information of potential importance to the investigation of the offence.

Body examination (extensive examination) means the examination interior of the human body (and also the taking of samples from the human body and examination of such samples). A body examination may not be conducted in such way as the examinee is at risk as regards future health or injury. Only a physician is allowed to perform an extensive body examination and of course it has to be performed at a hospital.

The decision to carry out a body examination must be made by a public prosecutor. The person who shall be subject to body examination may be held for this purpose for up to six hours or, if there are extraordinary reasons, a further six hours. In most cases the person is arrested (in legal terms). A customs officer (or a policeman) may use force to make it possible to accomplish a body examination.

After the decision from the prosecutor, the customs is taking the suspect to a hospital. In Gothenburg, fro example, we have now an agreement with one specific public hospital, which we are using for all cases of body examination. According to that agreement the suspect is always taken to the radiological clinic first.

At the radiological clinic a competent radiologist make a judgement of which kind of x-ray examination would be suitable in each case (abdomen survey examination, contrast examination or computed tomography). In Gothenburg computed tomography is almost always used. A competent nurse is performing the examination by "pressing the button", but a physician always makes the interpretation of the x-ray images.

If the x-ray examination leaves doubts about the result of the examination regarding the rectum and/or vagina, the radiologist may suggest vaginal/rectal palpation or rectoscopy if necessary. Such a decision is made in consultation with a surgeon or a gynaecologist and the examination is in such cases performed at either the emergency department or the gynaecology department.

According to new medical guidelines, a person shall always be taken in to the intensive care unit for observation if occurrence of drugs in their body is determined. This is a strict medical judgement and probably it is a result of the fact that we previously have had some rather serious incidents with "swallowers". Previously the suspects always were taken in to custody if the physician did not see any immediate risks.

In cases when "swallowers" or "stuffers" are kept in custody, we have to guard them very thoroughly and among other actions we have to search their remains of food and examine their excrements. It has happened that the wrapping of the drugs has started to leak and that can of course cause serious damage to the "swallower´s" health and emergency treatment is necessary in those cases. In Sweden we haven't had so far any fatal cases of illnesses due to swallowed drugs, but in some cases it has been very close.

As a crime fighting customs officer my opinion is that the extensive body examination in some cases is a necessity and we have not really got any adequate alternatives, unless the suspect immediately confess that he has swallowed or "stuffed" drugs. However the method is a point at issue and some questions that have been discussed are:

- Is it justifiable to use the method, as it is such a serious infringement on a person's privacy?
- Is it right to expose people with x-rays without medical indication?
- Is it in accordance with the medical ethics to perform extensive body examinations in order to search for drugs?
- Should we use our limited health care resources for such examinations?
- What are the alternatives?

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Session IV – Financial Gain

The Application of X-Ray Examinations in connection with the Assessment of Industrial Injuries

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In Denmark, the National Board of Industrial Injuries makes decisions in workers' compensation cases.

In many cases, the Board makes several decisions on different questions and these results in a total of more than 100,000 decisions every year.

In 2001, about 35,600 new workers' compensation cases were reported to the National Board of Industrial Injuries.

Approximately 20,000 were accidents at work (56 %), approximately 13,600 (38 %) were occupational diseases, and approximately 2,000 (6 %) were sudden lifting injuries.

Out of the about 20,000 accidents at work, there were

About 11,500 surgical disorders (58 %)
About 7,000 neurological disorders and back disorders (35 %)
About 800 medical disorders (4 %)
About 500 dental injuries (2 %)
About 200 other disorders (1 %)

Out of the about 13,600 occupational diseases, there were

About 1,400 skin diseases (10 %)
About 2,000 hearing disorders (15 %)
About 400 lung diseases (3 %)
About 1,700 shoulder and neck disorders (13 %)
About 2,600 disorders of the arms (19 %)
About 1,500 back disorders (11 %)
About 800 other musculoskeletal disorders (6 %)
About 1,000 mental disorders (7 %)
About 2,200 other disorders (16 %)

Decisions made by the National Board of Industrial Injuries can be appealed to the National Social Appeals Board.

On an average, about 10 % the Board's decisions are appealed to the National Social Appeals Board.
The Appeals Board changes about 10 % of the cases submitted to them for appeal.
Thus, only about 1 % of the Board's decisions are changed.

Furthermore, the National Board of Industrial Injuries makes advisory statements in private insurance cases involving personal injury. In 2001, the National Board of Industrial Injuries handled about 5,000 cases of private inquiries.

These cases pertain to liability for damages (about 4,500 = 90 %), as well as private accident insurance (about 500 = 10 %), where the parties to the case are unable to reach an agreement on the amount of the compensation.

About 4,300 (86 %) were laid before the Board at the request of an insurance company, and about 700 (14 %) at the request of attorneys and others.

About 1,400 of the cases (28 %) were about the consequences of whiplash-associated disorders.

Under the Danish Act on Protection against the Consequences of Industrial Injuries, the injured persons must:

1) As soon as possible after the occurrence of the industrial injury submit to an **examination** by a doctor and then follow the medical treatment or training that the doctor or the National Board of Industrial Injuries finds necessary.
2) If necessary, have themselves **admitted to a hospital** or a similar institution for observation.
3) If the Board asks them to, have themselves examined by a doctor appointed by the Board.

This should be seen in connection with another provision of the Act, from which it appears that if the injured person does not meet the examination requirements set out above, or obstructs treatment by disregarding given directions, the compensation may lapse in part or in full (duty to limit loss).

The duty to limit loss is found everywhere in insurance law and legislation pertaining to damages.

So the injured person is under an obligation to be examined by a doctor.

There is no obligation for the injured person to undergo any invasive intervention, such as an operation or arthroscopy.

The question of whether an injured person is entitled to refuse an x-ray examination depends on whether, according to a medical assessment, the examination exposes the person to any immediate risk. This is for instance the case if the injured person is pregnant.

Regardless of whether the refusal to be examined is justified, it will have a negative effect for the injured person if the necessary data cannot be produced in any other way.

In that case, the case will be decided on the basis of the available information, maybe involving a rejection of the injury.

In practice, however, in case of a justified refusal to be examined, the matter will be regarded less strictly. This means that the injured person will get the benefit of the doubt.

In connection with insurance medicine, there may be different reasons for requesting an x-ray examination:

1. In order to make the correct diagnosis
2. In order to assess the causality between exposure and disease
3. In order to exclude other causes of the disease
4. In order to assess the significance of pre-existing disorders
5. In order to assess the degree of permanent injury
6. In order to assess any later deterioration of a disorder

Re 1)
A radiological examination can be necessary in order to make the correct diagnosis for a reported disorder. For instance the difference between sprains and fractures can be confirmed or denied radiologically.

Re 2)
A radiological examination may be necessary in order to assess the causality between an exposure and a disorder. For instance lung cancer diagnosed after exposure to asbestos can give grounds for causality.

Re 3)
A radiological examination may be of significance for the exclusion of other disorders as causes of a reported disorder. For instance a radiological examination can exclude a slipped disk in connection with back pain.

Re 4)
A radiological examination may be of significance for an assessment of pre-existing disorders.
For instance a radiological examination may establish pre-existing arthritis of a joint prior to the injury in question.

Re 5)
A radiological examination may be of significance for the rating of a permanent injury. For instance a radiological examination may establish the number of fractured vertebrae as well as the severity of such fractures.

Re 6)
A radiological examination may be significant for the assessment of any subsequent deterioration of a disorder. For instance a radiological examination can establish the development of arthritis of a joint that has previously been injured.

Previously, the National Board of Industrial Injuries collected a large number of x-rays.

It was standard procedure, for instance in connection with fractures involving joints, to collect x-rays after a number of years, for the purposes of seeing if any deterioration had occurred, for instance arthritis of the joint.

Now we abstain from these routine examinations and make an assessment in each case of their necessity. X-rays are only a "shadow of the truth". The case is assessed on the basis of the injured person's complaints and the objective findings, and less on what the x-rays show. As will be known, a person may feel a lot of pain in a joint though there are only few radiological signs of arthritis, and only a slight pain in a joint with severe radiological signs of arthritis.

In the past five years, the National Board of Industrial Injuries has considerably reduced the number of x-rays collected.

In the 5-year period from 1st May 1992 to 30th April 2001, about 161,000 workers' compensation cases were recorded:

About 96,500 accident cases
About 64,500 cases of occupational diseases

In the same period, about 1,000 requests for x-rays were distributed on:

About 450 accident cases
About 550 cases of occupational injuries

This means that, on average, x-rays are collected in approx. 0.5 % of the accident cases and approx. 0.9 % of the cases pertaining to industrial injuries.

This corresponds to a total of 0.6 % of all cases.

However, this is only an indication of the number of cases in which the Board collects x-rays on their own initiative.

In a large number of cases we collect the x-rays that are already available from hospitals and medical specialists.

In this way we prevent new x-ray examinations if there are already x-rays existing that can be used.

Conclusion:
The National Board of Industrial Injuries seldom collects x-ray examinations (in 0.6 % of all cases)
The National Board of Industrial Injuries collects x-ray examinations only when it is absolutely necessary
The National Board of Industrial Injuries makes an assessment in each case of the indication for collecting x-rays
The National Board of Industrial Injuries frequently “recycles” x-rays in connection with the injured person's treatment in hospitals.

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The Implications of Medico-Legal Exposures in Different Contexts: A Legal Analysis

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Introduction: The Law's Approach to Competing Ethical Considerations

Those who are not lawyers sometimes look to the law for guidance in the resolution of ethical debate. They tend to find that the law has little distinctive to offer other than a coherent framework in which the ethical questions can be formulated. Their resolution, even in specific legal contexts, depends ultimately on metalegal considerations, drawn from ethical discourse and social policy.

At the heart of Directive 97/43 is the challenge of reconciling benefits and harms, actual or prospective, in particular contexts. These benefits and harms may relate to physical health, which in principle is measurable, or to wider personal concerns of an individual (such as family relationships and the acquisition or loss of wealth), or to the relationship between one individual and other individuals or the common good. Medico-legal exposures often occur in the latter context, but the philosophical question of how benefits and harms of different kinds are to be calibrated relative to each other is a wider one.

The tort (delict) of negligence involves a legal framework for analysis. In determining whether particular conduct, in which the defendant engaged, was negligent (i.e. lacking in the care that a reasonable person should take in his or her relationship with others and with society) the court must have regard to four factors:

- the *likelihood* of injury occurring;
- the *gravity* of the threatened injury;
- the *social utility* (or lack of social utility) of the conduct in question; and
- the *social or economic cost* involved in preventing the injury from occurring.

This framework gives no specific guidance as to whether the court should adopt a nakedly utilitarian philosophy or modify it by other considerations, such as a greater respect for bodily integrity over profit. Legal precedents accumulated over time may give legal advisers some confidence in predicting how a future case will be decided but they do not foreclose what is essentially an ethical debate from taking place before the court, within that framework.

The matter can be addressed in a number of specific contexts where medico-legal exposures may be contemplated in circumstances where there is a prospect of financial gain for one party, or all parties concerned. I will select three: the employment relationship, insurance and litigation.

The Employment Relationship

The relationship between employer and employee involves moral and legal duties on the part of both employer and employee relative to each other. In most jurisdictions, employers owe a legally enforced duty to take reasonable care for the physical and psychological welfare of their employees, in relation to:

- the safety of the premises where they work;
- the safety of the equipment they use;
- the competence of their co-employees; and
- the safety of the system of work under which they are employed.

The question of the health or medical condition of a particular employee can arise in a number of contexts in the employment relationship:
- before the employment relationship begins, when the employer may seek to be satisfied either that the prospective employee is in good health generally or that the prospective employee has the particular health or physical profile necessary for the particular tasks that the job involves or for the particular work environment;
- during the course of the employment relationship, to monitor the employee's health or medical condition, either to ensure that the employee retains a general capacity to discharge the duties that the job entails or to ensure that the employee has not been affected detrimentally by the particular work environment.

In the context of either of these situations, the employer may wish to expose the employee to ionising radiation. The motivation may include an element of paternalistic concern for the employee's welfare and to that extent may be regarded as therapeutically motivated but, when analysed dispassionately, it contains a substantial medico-legal content, as it is designed to ensure that the employer discharges a legal obligation to the employee and is thus protected from the possibility of being sued by the employee.

The employment relationship involves a contract between the parties and it might therefore be argued that the values of autonomy and free choice underlying the concept of contract mean that the question of the employee's exposure to ionising radiation is a private matter to be determined by the consent of the parties. Just as a person is free to choose a category of employment with enhanced risk (such as that of a test pilot, diver or soldier), so, it might be thought, a person is free to accept or reject the terms, as to exposure to ionising radiation, which a prospective employer proposes.

As against this, the courts and legislatures of many jurisdictions have for long been sensitive to the relative inequality of bargaining power that characterises many employment relationships, reflecting a wider social inequality. For more than a century, there has been judicial hostility to the widespread application of the concept of voluntary assumption of risk (*volenti non fit injuria*).

Moreover, there is an increasing social concern, reflected in court decisions, about compromising health in the interests of commercial profit. Health and bodily integrity are generally regarded as worthy of legal protection from commercial contractual arrangements, especially between parties of unequal bargaining power: cf. legal prohibitions on the sale of body parts and of commercial surrogacy contracts.

Insurance
Exposure to ionising radiation has traditionally been an element of the relationship between insurers and the insured:
- before the insurance contract begins;
- during its currency;
- when a claim is made on the basis of the insurance contract.

In defence of this traditional approach, it may be argued that the essence of insurance is an assessment of risk and that such assessment cannot be made with sufficient accuracy in the absence of access to the practice of exposing the prospective or currently insured person to ionising radiation.

As against this, other factors must also be considered. First, people obtain insurance in some cases, not because they particularly want it, but because it is an essential prerequisite of something that they do want and need, such as a mortgage to purchase a home or a large consolidating bank loan to pay off pressing creditors. Far from being in a take-it-or-leave-it situation, they are under strong pressure to take it, however onerous the terms may be.

Insurance is thus a zone with a potentially high risk of inhibition on freedom of choice by the insured.

A further factor may be noted. In contrast to most other contracts, insurance contracts involve the principle of *uberrimae fides* – the requirement that the prospective or current insured act with the utmost good faith. If he or she does not, and fails to disclose a pre-existing medical condition to the insurer, the insurer may repudiate liability. The law in this context operates strongly in protection of the interests of the insurer. This factor reduces, though admittedly does not completely remove, the need for the insurer to take steps before the commencement of the contract to identify factors, which may have a detrimental impact on the health of the prospective insured party.

It should also be noted that, whereas a prospective employee, faced with a level of exposure to ionising radiation which is unacceptable for him or her, may always seek alternative employment, the range of choice among insurance companies for a prospective insured may be very much more restricted.

Litigation
Litigation may not, on one view, be considered to involve financial gain, since, on principle at least, it is concerned with the vindication of rights and reparation for wrongs rather than the acquisition of a financial gain on the part of the litigant. Nevertheless, in practice, litigation has a significant financial dimension. The amount of compensation awarded for physical injury sustained as a result of another's wrong (tort, delict or breach of contract) can be very high.

Exposure to ionising radiation is a feature of the litigation process. A plaintiff must establish all the elements of the case on the balance of probabilities. These include:

- the commission of a wrong by the defendant;
- the sustaining of an injury by the plaintiff;
- a causal connection between the defendant's wrong and the plaintiff's injury;
- the quantum of damage already sustained, and likely to be sustained in the future by the plaintiff.

In respect of each of these five elements, exposure to ionising radiation may be considered necessary.

A plaintiff seeking to vindicate his or her rights through litigation is not obliged to subject himself or herself to unreasonable risk. He or she is free to decline to be x-rayed for whatever reason. The court cannot compel a plaintiff to be exposed to ionising radiation. It will, however, draw such inferences as it considers proper from the plaintiff's refusal. A plaintiff who refuses out of concern for the potential risks involved can seek to convince the court, first, that this is indeed his or her true concern and, secondly, that such concern is soundly based on science. The problem from the plaintiff's point of view is that the current culture of litigation in any particular jurisdiction, with which the judiciary of that jurisdiction will be familiar, may well favour taking x-rays in this context. The individual plaintiff, fighting against that culture, may be perceived either as a crank or a dissembler. In either case, there is a real possibility that the outcome of litigation may be less favourable for him or her than if he or she had chosen to undergo the exposure to ionising radiation.

Proposals for the future development of the law

The problem with the existing legal position in many countries is that the culture that has developed in specific contexts, where medico-legal exposures tend to be the practice, has not so far been greatly affected by changes in thinking within the world of expertise of those who administer ionising radiation. The courts are unlikely to change that culture in the short, or even medium, term since judges are familiar with it and may tend to regard it as part of the natural order and since individual litigants may emperil their financial interests in seeking to disturb it.

The two most promising avenues for reform are (i) legislative and (ii) professional/vocational. Legislation can give more detailed guidance as to practice in specific areas of the law. For example, it can prescribe the approach to be adopted in the context of medical examinations for the purposes of litigation and make it plain that a litigant is entitled to decline to subject himself or herself to exposures on a scale wider than thus prescribed. On the professional/vocational side, the professional and vocational bodies must be encouraged – and if necessary, prodded – into doing more to depart from their old ways.

It has been observed (by Nigel Harris, 'Medical Negligence in Trauma and Orthopaedics', Chapter 25 of M. Powers & N. Harris eds, *Medical Negligence* (2nd ed, 1994), para 25.22) that:

"… the threat of litigation has persuaded junior doctors in particular to X-ray more frequently than is perhaps necessary (a form of defensive medicine), and the effect has been that less reliance has been placed on careful clinical examination and judgement."

This culture of 'defensive medicine' can be transformed. It may be necessary for the legislature to contemplate changing the substantive rules of medical negligence to achieve such a transformation.

Legislation can also give detailed guidance to employers and insurers as to ways in which they can reduce the risks for employees and insured persons in specific contexts identified by the legislation.

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Ethics and Legal Aspects

Alain Pütz

France

The fundamental question raised by the contributions we have heard so far remains what are the limits of exposures with ionising radiation, in respect of medico legal approach.

It is a great honour for me to have the opportunity of addressing you at this symposium and sharing some thoughts with you on this very difficult problem.

It is also a great pleasure to come back to Dublin where I staid many years ago for a stage at the Director of Public Prosecutions' office with Eamon Barnes.

It is not frequent that a judge attends a so prestigious medical seminary. I would like to express my gratitude to Mrs. Marshall-Depommier and to the members of the organisation who invited me.

The study of History shows that Justice has used to be often close to Medicine regarding some parts of methods which are sometimes quite the same. In this respect, let me tell you a quotation of a philosopher who wrote in the past that if the physician has to cure the body of a man, the judge has to cure the body of society. Today, together, medical doctors, judges and, generally speaking, civil servants, we have to deal with this particularly intricate topic.

If we now turn to the actual problem, we are immediately struck by several items:

- the necessity of the forensic exposures with ionising radiation; but what do forensic exposures mean?
- the protection of people, in accordance with internal law and the Human Rights;
- the diversity of legal systems;
- the requirement of carrying out a balanced answer.

These points mean that there is clearly a paradox we have to deal with.

There is a second difficulty. According to their own rules, the medical doctors have to cure, to control the actions of other physicians or to be an expert.

In the field of medico legal exposures, they often have to obey directives of some authorities in order to get essential information, using techniques, which can cause people cancer or other dangerous diseases.

Nevertheless, if the use of ionising techniques in the name of the law is a necessity to protect the society and persons themselves, this use must be kept watch over to avoid going out of control.

According to the ethics, legal and judicial aspects, my remarks will fall under two main headings. I shall deal first with how we came to be in the present paradox and I shall examine the legal aspects and possible new guidelines.

What lies at the heart of all situations is diversity. Most of the Administration Departments need a medical examination. They are facing with security problems. But their actual aim is often different.

For instance, customs officers have to deal with the protection of the economy of the country or the EU economical problems. To get that aim, they can control people, trucks, containers to collect unlawful goods, particularly drugs. They generally act without any judicial control, excepted when they arrest someone. In this case, the prosecutor, the DPP's office or a judge has to deal with it.

Immigration officers control passengers to avoid illegal immigration.

In the same way, the police and the airports or harbours security agents are looking for weapons, drugs and, generally speaking, criminal facts to avoid terrorism and criminality.

In most of these cases, there is no medical problem stricto sensu. But we daily need technical exams in order to carry out arrests, to control the age of the offenders if they have no document, and sometimes we ask a doctor to exam a person who has been injured during arrest.

The determination of the age is a necessity - I should say a fundamental right, because proceedings and possibly penalties are quite different between adults and young people.

That is a very important problem for Justice because the determination of the actual age of young people is fundamental. For example, in France, if we have no certainty about the age, there is an obligation to consider young people as a juvenile. This means that if the young has committed an offence, he would be sent for trial before juvenile courts instead of normal courts. The penalties are also quite different… In the same way, the French Minister of Interior (the Home Office), may not decide to send a minor off the territory, if he is in unlawful conditions. So, in these cases, we need a medical age assessment with reliability.

Unfortunately, the radiologists rightly say that the accuracy is low, particularly between 15 and 18 years old and it costs much money. It is a pity because in most of the countries, theses ages are particularly important according to the choice of proceedings.

Therefore, the judge needs experts. To put it simply, without focusing on this point, I would say that there are two main expert systems. The expert witness carried by the parties and the expert appointed by the judge. It is interesting to observe that England and Wales, and perhaps other Common law countries, have been adopting both systems for several years.

I was struck by the remarks I have heard yesterday, concerning the actual mission of the expert in connection to the judge's labour. First of all, the expert is not a judge. He has not to appreciate the claim of a plaintiff, even if some asks him for it. According to his science, ha has to answer the questions or to describe the lesions, their importance, their consequences in their medical aspects and eventually, he can give an opinion about money compensation.

Turning on practical aspects concerning the age, the medical expert has only to answer a question. Is this man or woman 16 or 18 years old? According to my opinion, he has to explain the method he used to deliver the information and he has the obligation to mention the lack of accuracy, particularly between 15 and 18 years old.

The expert must not be nebulous and he has to do his job, according to what we call in French "les données acquises de la Science". It means the present medical knowledge at the time of the event, of the
Injuries, or the examination in the age field; I mean not at the time of a possible trial.

In other words, the expert has not the obligation to determine an accurate age, if he cannot give it. However, he must indicate the margin of error. If he does not mention it, he could make a mistake regarding the Code of medical practice or the proceedings rules.

These remarks lead to the responsibility of the experts. That very important topic is very complex, depending of the legal status of the doctor who has performed the exam.

This is depending on whether he obeys an order of the Administration, or if he is carrying out a judicial decision. In the first part, there is a requisition. In the second part, he is requested as an expert. Indeed, in most of the cases, the doctor cannot refuse the mission, excepted for exceptional reasons, but he actually has the choice of the techniques he wants to use to get the information

Depending on the local procedures, the expert writes a report or verbally explains the case before the Court. Then, the judge alone will decide.

The physician who is requested to do exams has not the possibility to do everything. However, he can be responsible only for what he has done wrongly by himself. In other words, he could not be responsible if he would not be able to control the exams carrying by someone else. If he does not perform them himself, or if he cannot control the exams, I think he has to refuse the mission and he must not sign the report. Nevertheless, if he does, he would make a mistake.

Indeed, the lack of specific law in some countries does not prevent someone, from suing the doctors for damages in connection with a possible irradiation or accident. For instance, I mean an anaphylactic shock with CT.

Anyway, the plaintiff, who will try to be compensated for a wrong done to him, will have to demonstrate that the injuries are in direct, total and exclusive connection with the medical examination. In these cases, it is not easy to work out the damages should be, particularly when the claim is for damages for personal injuries sustained in an examination accident.

Therefore, compensation for pain and suffering is nebulous and not easy to quantify. If the plaintiff has a very dangerous disease, he would have been entitled to very much larger sums of compensation.

Who will have to pay? The doctor himself, if he made a mistake. I mean the insurance company, excepted if he made an important professional misconduct. In that case, he could be on trial before a professional court or a penal court. The Administration can be sentenced itself, if no fault has been committed by the doctor who obeyed an order from it. I mean only for risk. This point depends of the legal system. Another solution is possible. The Administration can be sentenced to pre pay damages in case of medical mistake committed by a doctor who had been requested by it to practice the exams. The aim of this possibility is to be sure that the plaintiff shall receive money compensation.

In the connection of age determination, there is a great deal of concern about a medical consensus to get a better efficiency and to prevent the risks. It is an important task. The researchers would be taking steps to ensure that the techniques do not lead to side effect for the patient or people working in the area.

This is a fundamental and ethical topic because the question is we have to take care when we deliver irradiation to get information and possibly kill somebody. I am not sure we are attentive enough to quality of equipment and training of practitioners.

The different treaties and Declarations of human rights, particularly the Treaty of Rome and the European Convention of Human Rights signed in the fifties on behalf of the Council of Europe do not specifically mention the right to health, excepted some sector-based stipulations. However, the European Court of Justice and the revision of the European Union Treaty and the Treaty of Amsterdam emphasized this topic and reminded the importance of these fundamental human rights.

In conclusion, in this short survey of legal aspects of forensic exposures with ionising radiation, we have obviously noted that these techniques could often be dangerous and in some fields dangerous and not accurate.

Do we have to suggest that commissions with doctors, engineers and judges should seriously control the different systems, which have usually performed in these fields? Then, the judges would be able also to deal with the abuses of power committed by some administrations that disregard the regulations on the ionising exposures.

However, I am confident. The efforts of the European Commission and participants will be rewarded with concrete and practical results. We need to be attentive to reach a consensus on the ways and means to achieve an effective system with few risks.

However, I am afraid because in this field, quality has no price. I mean, it costs much money.

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Session V – Protection of Public Health

The Use of Diagnostic X-Ray Techniques in Immigration and Emigration

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The use of chest radiographs to determine whether immigrants or emigrants have active or past Tuberculosis (TB) is an established technique. The paper considers the justification of such exposures in relation to the individual and society.

For immigration the factors considered include:

a. the justification process
Justification in these cases involves the potential benefits and detriment to both the individual and society. The practitioner who justifies the exposure may be different for Member States – a factor will be whether the exposure takes place within the port of entry or at a local healthcare facility. The degree of training for the practitioner may be influenced by the process and the type of installation.

b. the position of these exposures within the legal system
Consideration will be given to the requirements for the exposure as part of the legislation or within an associated administrative process. Is the exposure mandatory or voluntary? What enforcement powers exist to ensure that the exposure takes place?

c. the basis and ethics associated with the examination
What selection criteria are used to select asymptomatic patients (e.g. country of origin)? Is the process observed at every port of entry?

d. the consequences of these exposures
If TB is suspected or proved, what consequent action takes place? Must the entrant receive treatment as a condition of entry? Is it ethical/humane to return the entrant to the country of origin and what are the implications for fellow travellers? In what way does the consequent action influence the justification process?

e. which examinations are diagnostic, medico-legal or health screening
If examinations are considered to be preventative, how does this influence the categorisation of the exposure? Is it important to categorise the exposure?
Consideration is given to asymptomatic and symptomatic entrants.

For emigration, how does the legal requirement of the country of destination influence the practice and justification in the home country? Clearly there is justification for the individual and society in the country of destination on economic and social grounds but how is the justification influenced by the prevalence of TB in the home country?

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Health and Employment. Human Rights Aspects

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This paper deals with the ethical and human rights aspects of the application of the Directive 97/43/EURATOM of the Council of 30 June 1.997 about radiological exposures for checking up the health of the workers or in the screenings of health. Most of the considerations will be valid also to the radiological exposures with medico-legal purposes.

First of all, it is important to define the concept of health, and then to consider the limits of the autonomy of the exposed person in connection with the preventive and public health use of radiological examinations.

To be in good health does nor mean to function as a biological model. From our point of view, health is a physiological and mental balance that allows the age related development of the individual, and the implementation of a responsible personal vital project, with loyalty and solidarity towards the other members and institutions of the society.

The employment is a contractual relation for the fulfilment of a task or activity by a person, the worker, under the terms agreed upon by the parts in conformity with the law.

Human rights are valid moral claims guaranteed by the state to enjoy certain benefits and values recognised in the given society.

Historically, the human rights have been recognised in the following order:

Natural rights, associated with traditional liberalism. Those are rights to life, privacy, free political opinion, non discrimination by race, sex or convictions, liberty, justice, pursuit of happiness, founding of a family, etc. To those, we should add the recognition of the human dignity. In fact, those are rights of non interference with the personal autonomy.

Political and civil rights, like the right to vote, of citizenship, residence, participation in the political life, emigration, etc.

Social and economic rights, including health services, work or unemployment, strike, clothing, housing, minimum standard of life, etc.

Cultural rights, as the right to education, to traditions, to language, etc.

In this development it should be noticed that the oldest rights refers to abstention of interference with the personal autonomy. Later on came rights requiring productive interventions by government. Then, the social rights guarantee the freedom from need and the basic support for every one.

In the most advanced societies, the human rights are consistently applicable and enforceable, even against the institutions or the state. This corresponds to the situation in Europe. Unfortunately, the human rights implementation depends very much of the cultural tradition, economic situation, political structure and, last but not least, moral, social and political standards.

The radiological exposures for non medical purposes bring the concept of risk as a kind of aggression against the right to health and to the autonomy, in accepting or not an intervention in the human body.

But to speak of risks without evaluating it, and to give guarantees without relating the reason for the exposure, to the justified benefits reported by the procedure under scrutiny, is senseless.

We all are entitled to the pursuit of our own interest and to have our own rights and freedoms respected, but if there are rights is because there are duties. If every one has a share on the benefits of living in an advanced social society, every one has to accept some hindrances and limitations.

In most of the situations that may justify radiological exposures for non-medical purposes, the subject may refuse to be examined. Unless there exists a valid justification for the refusal, this may involve losing some expected benefit, but the person autonomy will be respected with the exception of a strong public health or legal reason which may force the involuntary medico-legal procedure, decided by a legally entitled authority and performed under medical control, or by a physician.

In those cases, the justification for the exposures should met standards or rationality, including the reasons, limitations and exceptions.

Among the limitations, we can mention, the possibility of previous exposures with the same finality, making the new exposure redundant and unnecessary; and among the exceptions, some refer to conditions like the possibility of pregnancy.

An important human right issue is equity. Equity has to command the decision and also in the way of implementing it, like the way and extent of the provided information, previous to obtain the consent and the non-discrimination in the human communication.

Also important are the guarantees taken to ensure, not only that all the procedures have been duty performed, but that there is documented evidence of the adherence to the appropriate guidelines and standards.

Habermas has proposed a logical universal pragmatics based on a transparent communication, and the way to analyse a possible conflict should be such as deserving the agreement or free and independent citizens. This corresponds to the test of free and open examination, which in fact should be performed through another instance, with the power to reconsider the first decision.

Today, the best guarantee talking about human rights is to reconceptualizing them, in order to implement them within a clear regulatory framework, which should include the rights, the procedures to realise them, the information about the tramitation, the conditions and exceptions, and the possibility of recourse.

Ethics is not only a matter of personal coherence with a system of values, but involves also, the respect for the opinion of other parts and no seeking an undue advantage.

Conclusions
Not all human rights have the same ground. Some of them are natural and fundamental. Some are institutional based in human needs. In some of the, the state has a subsidiary role. More advanced is a human right, more is liable of limitations and exceptions.

The paradox of work is that instead to be a source of self-realisation and health; it may be a source of illness and death.

The use of radiation for no medical purposes involves risks, but the term risk is inherent of any human activity. Some negligible risks should be accepted when this acceptance has moral grounds, rational justification and would pass the test of free and open examination.

In those cases some measures of coercion or some limitations of enjoyment or rights, are justified.

The non-medical indications of the use or radiation at the end should benefit the society, if not always the subject itself. Under those circumstances, the moral and legally established guarantees for the person must be very high.

Non medical uses of radiation, as well as other measures of mandatory preventive examinations, have to be used having in mind their strict finalities.

It would be an abuse to transform the check-up of health in an instrument for undue discrimination, or vulneration of the personal rights.

The risk of inequities in the application of the norms should be positively avoided and among the guarantees of quality in those, fairness is fundamental.

Norms limiting some human rights should be applied having in mind the spirit and purpose of the law. To act otherwise, is to act unethically and may be a fraud or law.

Medical and non medical uses or radiation have some things in common: rational justification, case by case indication, subjection to norms of procedure need to inform and to act with due consent, with some exceptions that have to be expressly included in the law and high standards of quality.

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Summary Report of Sessions I-V

EXPOSURES IN THE NAME OF THE LAW

An International Symposium on Medico-legal Exposures

4 – 6 September 2002, Dublin, Ireland

The reports that follow were prepared by the rapporteurs of each of the sessions. As the full presentations have been provided either as handouts, a written paper or as short notes, these reports reflect (i) a short summary of the content and the opinions of the speakers (ii) the comments and opinions of the audience and (iii) the opinion of the individual reporters, based on a total impression. The reports were discussed in the final session in order to give the audience and the speakers the opportunity to comment or disagree with the reports. In those (rare) cases, the current reports have been changed or will reflect that difference of opinion.

Report of Session I – Scope of the Meeting

Chairperson and Rapporteur: Mr Steve Ebdon-Jackson

Mr Ivor Callely (Minister of State, Department of Health and Children) welcomed delegates to the meeting and offered his best wishes for its success, praising all those involved with the organisation of the event.

Mr Stephen Kaiser (EC) responded and went on to put into context the importance of justification within medico-legal exposures.

Mr Steve Ebdon-Jackson explained that the first session was intended to provide an introduction to the meeting as a whole. The first two speakers had been asked to give some scientific and legal background to the meeting and introduce some specific issues relating to medico-legal exposures within the framework of the Medical Exposure Directive and radiation protection principles. The second two speakers would then outline the results of a questionnaire designed to understand Member States' views and approaches to a range of medical exposures that might be considered as medico-legal exposures.

Dr Ciska Zuur outlined the importance of medical exposures within the context of radiation exposures received by man. She outlined a range of exposures that might be considered as medico-legal exposures and raised issues as to whether all of these are justified and how justification of these exposures might consider different factors to those exposures intended for diagnosis. Dr Zuur recognised the different backgrounds of the delegates and provided a basic introduction to ionising radiation, radiobiology and the major elements of radiation protection.

Ms Blanca Andrés Ordax (EC) discussed the implementation of the Medical Exposure Directive 97/43/Euratom with regard to medico-legal exposures. She outlined the requirements of the Directive while pointing out that the method of implementation was a matter for each Member State. Although the Directive included a definition of medico-legal exposures, Member States' national legislation has not defined medico-legal exposures in a consistent manner. This inconsistency was not restricted to medico-legal exposures. There were also marked differences in the way "special attention" and "justification" had been approached and how responsibilities and procedures are described and allocated. In conclusion, Ms Andrés Ordax felt there was a need for clearer definition of terminology and responsibilities.

Drs Elisabeth Marshall–Depommier and Wolfram Leitz discussed the questionnaire designed to identify Member States' approach to medico-legal exposures. Their talks identified the process and difficulties associated with producing a questionnaire and discussed issues relating to the responses.

Dr Marshall–Depommier explained that the background and intention of the questionnaire was to provide a clearer understanding of what were considered to be medico-legal exposures in each Member State. She explained the outline of the major elements of the questionnaire, indicating potential areas of confusion.

Dr Leitz then provided the results of the questionnaire, paying particular attention to the sources of uncertainty. He gave samples of the questions posed and from the responses, highlighted some of the questions that respondents had found confusing. He provided illustrations of different interpretations of legal provisions.

The Discussion Session was led by **Mr Steve Ebdon-Jackson** and resulted in lively and widespread debate and an introduction for the rest of the meeting. Discussion was framed around the design, interpretation and findings of the questionnaire, implications for harmonisation and the identification of a need for further work in this area.

In conclusion, there was support for a repeat of the questionnaire, but delegates agreed there was a need to include responses from a range of stakeholders. This would need co-ordination at Member State level to prevent multiple opposing views from each country. It was agreed that in any further questionnaire, questions regarding legal issues and processes need to be better defined.

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Report of Session II - Exposure of Children, Health Determination

Chairperson : Dr Ciska Zuur
Rapporteur : Dr Peter Grøn

Dr J. F. Chateil opened the session with his presentation on age determination. Age determination can be used by authorities when no birth certificate is available to verify age. This is particularly necessary in cases involving adoption, asylum and illegal immigration. Assessment of age using radiographic techniques involves skeletal or dental surveys. The radiation doses for these examinations are low compared with most routine radiographic techniques. Both dental and skeletal age determination methods are limited by their accuracy, with established error ranges of plus or minus one year. This has significance when determination of age is critical to status e.g. 18 years old where subsequent decisions can have significant legal and social implications.

A number of other techniques have been evaluated. Of these MRI has shown promise but requires further investigation and validation.

During discussion, delegates held the view that this type of procedure should be considered as medico-legal. There is no medical reason for this type of examination, as these exposures cannot be considered as having diagnostic benefit. There may be significant social and economic benefits for the person examined, however, as issues such as legal status, adoption, asylum etc often rely on the specific age of the subject.

The accuracy of the procedures was highlighted as a major concern. The validity of individual results depends on comparison with an established database of relevant ethnicity to the person examined. Those available for Western European and North American population groups have little value for many of the people requiring age determination. Given the uncertainty associated with the procedure, many of the delegates felt radiographic procedures had no role in age determination for persons at critical ages.

Justification of these examinations for an individual was considered to depend on the potential impact on the individual and society.

Dr. G. Hurley continued the session with a presentation on X-ray examinations in sports.

Athletes, whether competing at a recreational or elite level, once injured, become demanding and determined patients who require prompt and effective treatment. Sports Medicine is now a recognised speciality in many countries.

Sports injuries may be acute or chronic. The acute injuries resulting from sports are not different from other injuries. The need for imaging is required to confirm the clinical findings and exclude complications. Chronic injuries, such as those from overuse, are characterised by repetitive micro-trauma, which overwhelms the normal tissue repair process.

Routine screening is known to occur in the case of athletes and football players. One example is in the case of a transfer, where the football player has a financial interest in proving his (or her) fitness.

The discussion that followed considered whether x-ray exposures for this purpose should be considered as medico-legal or not. It was felt that for acute and chronic injuries, where a medical indication exists, the correct classification would be one of a diagnostic exposure. It was stated that there is a need for education of the radiologist regarding the value of imaging procedures for different conditions associated with specific sports. There were no comments on the use of routine screening and its justification.

During the discussion, a specific example was given by Prof Carty of a radiographic exposure required for participation in sporting activities. In some countries, requests are often received for children with Downs's syndrome to have an X-ray of the neck prior to participation in sport. This could be considered as a medico-legal exposure. Its main purpose however may be considered as preventative and the exposure may therefore be classed as a diagnostic procedure, justified for a sub-population with a known predisposition to a condition, even in the absence of symptoms.

Prof. Carty gave the final presentation of this session, which considered the ethical and radiation issues of imaging for suspected non-accidental injury.

In the 1920's the most frequent causes of death among children were disease based, whereas now accidents and murder account for the greatest number of childhood deaths. Prof. Carty gave details of the protocols used in her hospital when examining children who may have been subjected to child abuse. These protocols are very specific and follow strict guidelines and processes, involving a multi–disciplinary team. The total radiation dose is very low, with an estimated effective dose from 12 exposures of 0.12 mSv. The presentation highlighted the importance of protocols to ensure optimisation. It was essential that diagnostic radiographs were produced at the first attempt. The introduction of CR systems will have an impact on both the production of images and the radiation dose.

The role of the paediatric team, social services and others and the need for legal intervention were addressed. It was clear that the benefit of the child should always be the primary issue and the parents' position was very much of secondary importance. It is rare that parents do not consent to x-ray examinations for their children as doing so would indicate potential guilt. In the UK, the management of suspected child abuse includes rehabilitation and support for the family.

During discussion it was stressed that in justifying these examinations, the low radiation dose involved needs to be compared to the health and welfare of the child. These examinations can be considered as preventative and may be best regarded as diagnostic exposures. The range of exposures undertaken cannot be restricted to the area of presenting injury, if a comprehensive assessment is to be achieved. The importance therefore of an optimised approach to the whole protocol was paramount and demonstrated the synergy between justification and optimisation. It was agreed that exposures for young siblings may have a role and could be justified on a preventative basis.

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Report of Session III - Preventing Illegal Activities

Chairperson : Dr. Marshall-Depommier
Rapporteur : Dr W. Leitz

This session contained five contributions dealing with the use of ionizing radiation for preventing (or revealing) illegal activities.

Highlights from the presentations

P. Rothschild from the company American Science & Engineering introduced equipment based on backscatter techniques as an alternative to body search. The dose per examination is typically 0.1 µSv. Around 20 of these systems are in use at airports, prisons and borders. Tests to demonstrate the effectiveness of the system were performed at Montana State Prison. A drawback for a more widespread use is the invasion of privacy because the system creates "unclothed" images of the individuals exposed. Further development of the equipment is ongoing with a view to achieving shorter exposure times and increased detection capability of drugs and explosives. This will, however, increase the dose by a factor of about two.

H. Vogel, a radiologist from Hamburg, gave an overview of the use of ionizing radiation for checking goods and persons crossing the border. Equipment with different radiation sources is used to reveal contraband on and in people crossing borders. The decision for such a search is normally based on suspicions based on the person's behavior or peculiarities in the items transported. Interesting, from a historical perspective, were the activities in the former DDR. Cars and trucks passing the East-West border were secretly checked using fluoroscopy. Persons and vehicles were tracked by attaching needles with radioactive substances on clothes, shoes or tires. Manuscripts, documents and foreign currency were marked with radioactive substances in order to reveal who was handling these items. Today these exposures would certainly be declared as illegal exposures.

K. Rodgers and A. Ross from the UK Immigration Service presented the large problems associated with clandestine entrants, both for society and for the illegal immigrants themselves and discussed it in the context of the situation cross Channel. Equipment with transmission and/or backscatter technique is used for checking trucks and containers. The doses to persons hidden in the truck are of the order of 2 µSv. In Great Britain this practice was justified on the grounds of societal benefits (effective border control), indirect benefits for the people hiding in the trucks (discovery may prevent them from suffocating) and for economic reasons. It was stated that only the Basic Safety Standards (96/29/Euratom) apply and not the Medical Exposure Directive (97/43/Euratom).

M. E. Clark from the Environmental Protection Agency (EPA) gave an overview prepared by J. Lipoti from the New Jersey Department of Environmental Protection on the situation concerning weapons search in the US. Personnel security systems are not regarded as medical devices and hence don't need FDA clearance. The states have the authority to regulate devices in use. The states' radiation protection forum, CRCPD, passed a controversial resolution recommending the immediate discontinuation of exposing humans to ionizing radiation for non-medical purposes. Only when no alternative means exist should such activities be permitted. International guidance on these matters should be acknowledged.

T Magnusson from the Swedish Customs addressed the use of diagnostic x-ray techniques in dealing with persons who are suspected to have swallowed drugs. This normally relates to individuals crossing the border to another country. The prosecutor decides whether the suspect can be examined by x-rays and the examination is then performed in a hospital. It was stressed that a very high degree of suspicion must be present for this procedure to take place. In Sweden, positive findings occur in 20 to 50 % of the 50-100 examinations per year. Nowadays almost all examinations are done with computed tomography. Alternative methods include the administration of emetics (to provoke vomiting, not permitted in some countries) or taking the suspect into custody and waiting for nature to take its course.

Discussion

Search for weapon, drugs etc. outside the body
There was a general view that this procedure was of no concern from a radiation protection point of view because of the extremely low doses involved. However, concern was expressed that in the future such equipment could be in widespread use and installed in locations such as shopping malls, banks, official buildings, airports, warehouses etc. The United States is the only country where this practice is known to be in use at airports and in prisons.

Truck search
Arguments were put forward that the exposure might be considered to be a medical exposure because clandestine entrants might be saved from suffocation. However, the majority of the audience did not share this view. There was no consensus on whether there should be a difference between procedures where the primary aim is to find contraband (and discovery of refugees is incidental) and those where the aim is to catch clandestine entrants. Providing certain precautions were undertaken (giving adequate warnings, CO_2-tests etc.), the practice was generally believed to be justified.

Search for drugs inside the body
This practice was generally regarded as being justified, provided the degree of suspicion in individual cases is strong enough, i.e. such that a legal basis for body search exists. There is also a component of potential benefit for the swallower: The packaging (frequently condoms) can tear and the contents be released into the intestines, resulting in serious illness or death. Though it is ethically defendable to perform these exposures, the fact that resources are withdrawn from medical care must be taken into consideration. Spain reported that the legal framework in this area is such that the rights concerning personal integrity can be suspended. Plain x-ray radiography should be used in preference to computed tomography, which has a much higher associated dose.

Final remarks from the rapporteur
The use of ionizing radiation, for the crime-related purposes described, is considered to be justifiable. In the first instance, the protection of society is at stake. The potential damage caused by importation of drugs, hi-jacking of aircraft or illegal immigration normally outweighs the radiation risk incurred by the suspect, especially in view of the extremely low doses associated with the techniques normally involved (with the exception of swallowers where the techniques would not necessarily involve low doses). However, before such practices are introduced a number of issues have to be dealt with. The pros and cons of

alternative methods have to be considered. The criteria for selection of the suspects must be carefully evaluated in order to minimize the number of exposures of innocent people. Under normal circumstances, the examinations should be voluntary and there should be informed consent from the individual to be exposed.

Because all of the practices imply prevention or revealing of illegal actions, it is likely that they are medico-legal exposures. This is certainly true for examinations of "swallowers". Examinations of trucks and containers – with or without the declared purpose of revealing clandestine entrants – should not be classified as medical exposures at all. The view of the UK of regarding the Medical Exposure Directive (MED) as not applicable for this practice is obviously a correct judgment. For weapons and drugs search on the body, the picture is not so clear. If, it is regarded as medical exposure then according to the MED it is a medico-legal procedure. It could be argued that it is not a medical exposure, in analogy to the trucks.

An urgent task, for the near future, is to prepare for increased use of x-ray equipment for weapons and drugs search. The dose from a single examination can be regarded as trivial and of no concern. But what about multiple exposures? If the use of this equipment is widespread, individuals could be exposed many times every day. How should this problem with many sources, each giving trivial doses, be dealt with? International agreement should be aimed at because this is certainly an international problem.

All three practices dealt with in this session should be evaluated with regard to their effectiveness, dose and the alternative techniques available. Of special concern is the exposure of "innocent people" who do not derive any benefit for themselves and where the benefit for society is questionable. The selection criteria must be set so as to achieve a good balance between the effectiveness of the procedure and the number of people exposed "in vain". These issues must be addressed by close co-operation between the professions involved. The aim should be to provide guidance for the various procedures, if possible on an international or at least a European level.

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Report of Session IV - Financial Gain

Chairperson : Dr.P.Grøn
Rapporteur : Dr Ciska Zuur

The 4th session of this symposium 'Financial Gain' dealt with exposures, which could lead to some financial benefit. The benefit could be to the one exposed or to another. Included in this session also were some exposures, the benefit of which was other than financial.

The subjects and the speakers were 'The application of X-ray examination in connection with the assessment of industrial injuries in Denmark' by **Dr B Mathiesen**, Chief Medical Consultant at the National Board of Industrial Injuries in Denmark, 'The implications of medico-legal exposures in different contexts: a legal analysis' by **Professor W Binchy**, Regius Professor of Law at Trinity College Dublin and Head of the Law School and 'Ethics and Legal Aspects' by **Professor A Putz**, a Magistrate and a senior member of the French judiciary. There was also very active participation from the audience

1 The application of X-ray examination in connection with the assessment of industrial injuries in Denmark (Dr B Mathiesen, Copenhagen)

Dr Mathiesen is a medical doctor for an insurance company, which deals with occupational injuries. His particular specialty is orthopaedic surgery.
His paper therefore dealt specifically with this type of industrial injury. Most industrial injuries undoubtedly affect bones and for accurate diagnosis and assessment of these injuries, x-rays are often needed. Dr Mathiesen pointed out that in Denmark, as in many other countries, the injured person has the duty to limit the loss, in other words he must co-operate with or even initiate proper diagnostics. For almost all injuries, the diagnostics are welcomed and are not refused. Previous x-rays are requested and reviewed, before new ones are made, in line with 97/43/Euratom.

2 The implications of medico-legal exposures in different contexts: a legal analysis (Professor W Binchy, Dublin)

Professor Binchy divided his presentation into three different parts: (A) employment relationship, (B) insurance and (C) litigation. A summary of his presentation follows. The comments made during the discussion are also given.

A. Employment relationship

(Pre-)employment exposures can be divided into three groups:
1 the first group includes those exposures which are carried out to assess whether or not the worker is fit for his job, because of the potential danger to himself that would result from being unfit. This could be both for new and existing employment. One example would be, where an older worker was involved in heavy physical work. It is recognised that for example, an ECG is not very predictive but previously undiagnosed lung disease could be discovered by a chest x-ray.

In the discussion that followed, it was concluded that all of these exposures are considered to be occupational health surveillance and not medico-legal exposures. The justification of these exposures should be performed by the occupational health physician and the radiologist and should be based specifically on the individual benefit to the relevant worker.

2 The second group of exposures considered by Prof.Binchy were those exposures which are done to assess whether or not the worker is fit for his job, because of the potential danger to others, as well as himself, that being unfit would pose. Examples are crane workers: should the cargo fall, other workers could be hurt or even killed. Other examples are pilots, train and bus drivers. Another subgroup is people who are in close physical contact with other workers or members of the public. e.g. teachers, medical doctors, nurses etc. Should one of these workers have undiagnosed tuberculosis, the consequences for others could be severe

In these cases the exposure is judged to be occupational health surveillance and not medico-legal and the justification is based both on a societal and an individual benefit.

3 The final group considered in this section were healthy individuals who are required to have pre-employment exposures. In this case exposures are performed purely to avoid financial liability on the part of the employer who might have a (chronically) ill employee. In the discussion that followed, it was felt by the audience that these exposures fall into the category of defensive medicine and are considered to be medico-legal. The justification issue is somewhat more complex. It seems as if the exposures are only for the benefit of the employer and could have only negative outcomes for the employee and should therefore not be justified. However, many workers are happy to have a pre-employment medical assessment, including X-rays, as it reassures them about their health, especially when the outcome is a positive one.

Moreover, it is not always solely in the interest of the employer. If it is a relatively small company or institute, one or two quite frequently or chronically ill people can cause financial problems for the employer, sometimes even leading to bankruptcy. This influences directly the job of other 'healthy' people. Sometimes the diagnosis can even be an (in)direct benefit for the worker. The knowledge of having a disease is not pleasant, but might lead to an early and perhaps even complete cure

In conclusion, in most situations the exposure is justifiable, assuming appropriate referral criteria are used (This point is discussed in the General Comments on all of the sessions).

B Insurance

The next group of exposures discussed by Prof.Binchy were those that are made for insurance purposes. In insurance matters, most exposures are just medical: a hidden disease is assumed and the point of the exposure is to reveal this. This was seen by the audience as 'defensive medicine'. Insurance companies sometimes forget that insuring someone's' life is about taking risks. A person without a certain life threatening risk doesn't need to be insured!

However there is also some social benefit in minimising the risks. If most people with a relatively high risk were to be excluded from being insured or required to pay a higher premium, other people don't incur the cost of that higher risk and pay only for their own lower risk.

During the discussion that ensued, the following example was given. In the Netherlands, HIV tests are required for loans above about €100.000, e.g. for a house to be covered by life insurance. This is fully accepted and even welcomed both politically and by the public. One doesn't want to pay for someone else's diseases if that can be avoided, as one does already pay a certain amount through health insurance, which already reflects the diverse range of states of health of the insured group.

Exposures just to avoid risks are certainly medico-legal. The few exposures in the case of objective suspicion of a disease are not, they are medical.

In the case of medico-legal exposures, the justification is more complex. The benefit is normally not for the client, but it could be, in the case of an early diagnosis. There is certainly benefit for others, not only for the employer, but also for other people insured by the same company. As in all subjects in this matter, it depends also very much on the type of X-rays that are to be used. The discussion about referral criteria (see later) is also relevant here.

C Litigation

The final group considered by Prof.Binchy are those exposures that are carried out as part of a litigation process. This would include cases that end up in court with the objective of getting compensation for an injury past or present, for which some one else could be blamed partly or totally.

During the discussion, the following points and conclusions were made. In most European countries the intention is to compensate individuals who are found to have suffered injury, rather than to make large financial awards. Compensation usually includes a component for suffering or loss in future years. In assessing the appropriate amount, a judge, even with the help of expert opinion, can misjudge the likely impact of the injury and hence the appropriate amount that should be awarded. Compensation often results in psychological benefits even when the amount awarded is small. This derives from the sense that justice has been done and there has been a recognition and acknowledgement of the injury suffered.

In order to assess the extent of injury and consequences of that injury, x-rays are often required. It is clear that many x-rays are taken for this purpose. There seems to be little question that these exposures are justified. The benefit is to the individual exposed, who wants justice and often compensation.

It also seems clear that these exposures are medico-legal (assuming that normal medical care was given). Prof. Binchy warned about the possible adverse effects of labelling these exposures as medico-legal. He suggested that individuals might become reluctant to go through with them because of the negative association that might arise. If this impacted on the outcome, then justice would not be served. The audience took notice of this fear, but seemed did not fully share his concerns.

3 Ethics and Legal Aspects (Professor A Putz, Paris)

The first presentation was by **Prof.Putz**. His starting point was to state that forensic exposures are meant to protect people in accordance with Human Rights and within the framework of the law.

In considering exposures for age assessment, Prof.Putz explained the importance of being able to establish a person's age in legal proceedings. This is especially true for suspects between the ages of 10 and 21. Below certain ages, e.g. 13 in France, a suspect will not be prosecuted at all. Between 13 and 18 (or in some states 21), an individual comes before a juvenile judge. Persons over 18 (or 21) are brought before a judge for adults. A defendant's age can also influence the level and type of an eventual punishment.

Repeating his comments in a discussion on Wednesday, he warned that an expert, called upon to provide evidence on the age of a suspect, is not the judge. The expert should provide the judge with the scientific information he has gathered, including the uncertainties, e.g. the person is 18-year-old +/- 1 year. The judge balances the uncertainty with other information and comes to a decision about the age. In a later discussion, Prof. Binchy made the point that the judge doesn't have the answers but makes them based on information gathered.

Discussion and Conclusion:

In the discussion, the age determination was considered to be a medico-legal exposure. For injury assessment it depends on the circumstances: it is considered to be medico-legal if the exposures are purely performed for the purpose of the court and or to assess the punishment, or the compensation etc. If the exposures are meant to assess the most applicable cure, it is of course medically indicated. However, it is unlikely that such an assessment will be initiated by the court.

The justification of exposures performed on the initiative of the court is not entirely clear cut, but tends towards a positive justification. If it is performed to assess the age of a suspect because below certain ages the suspect will not be prosecuted or will be prosecuted as a child, and the suspect is indeed younger than the relevant age, it is clearly to the advantage of the suspect. If it turns out that the suspect is considered to be older, then it is clearly not to the advantage of the suspect. Such a suspect could, however, avoid the exposure by confessing his/her real age. There remains the problem of suspects who are in fact younger, but are considered to be older as a result of the age assessment. However, taking into account a reasonable uncertainty range and careful consideration by the court, this should not happen very often. In general, the age assessment of suspects is considered to be justifiable. However when the uncertainty in the assessment is too large for the particular age group, the technique is obviously inappropriate for that particular case and the exposure would not be justified.

For asylum seekers, the same considerations apply. However, in this case the justification will be even more positive because there is a societal interest and benefit for the country involved.

The age assessment of children in the case of adoption of children, who have been abandoned as babies, seems, in most cases, to be to the advantage of the children. It is psychologically bad for an individual to be treated as if one belonged to a different age group.

In all these cases the assessment should be as accurate as possible and all available techniques (appropriate to the age group in question) should be used to minimise the uncertainties.

Conclusion from Session 1V

In order to correctly identify whether an exposure is medico-legal or not, one must examine the reason for the exposure. If the exposure is performed mostly for diagnosis and to guide the cure of the injured person, it is a medically indicated exposure. If it is the case that the exposure is meant to avoid or limit damage for the individual worker himself or for others due to the injury, it is occupational health surveillance as has been discussed already under pre-employment exposures. If the primary objective in taking the exposure is to get compensation etc., then they are considered to be medico-legal.

The question as to whether or not these exposures could or should be justified can be answered positively for all cases – compensation (medico-legal), diagnosis and treatment (medical) and prevention of further or additional injury (occupational health surveillance).

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Report of Session V – Protection of Public Health

Chairperson : Dr Geraldine O'Reilly
Rapporteur : Dr Elisabeth Marshall-Depommier

Mr Steve Ebdon-Jackson introduced the session by highlighting that in this group of practices, benefit needs to be considered in relation to individual and public needs. In some cases, there may be no obvious physical benefit to the individual while the exposure will have some, but often small, associated potential detriment and this presents a particular problem with justification of individual exposures. In many cases the benefit to society or the individual will be economic and social.

It should be noted that in some circumstances, apparent freedom for the individual to choose whether or not to be exposed to ionising radiation would have significant social and economic consequences e.g. employment or the right to stay in the requested country.

In cases where there is direct or potential health benefit for the individual, it may be appropriate to classify the exposure as a diagnostic exposure. Alternatively, the exposure may be considered as part of health screening, within or outside a screening programme.

Mr.Ebdon-Jackson's presentation addressed the use of X-ray techniques in immigration and emigration. In both cases, the benefits and detriments to the individual and society must be considered. The paper considered chest radiography in the determination of active and past Tuberculosis (TB) – this being an established technique.

The classification of exposures will differ, depending on whether the potential entrant is symptomatic or asymptomatic and the basis of the x-ray – is it a Public Health safeguard or a trigger for deportation?

For the symptomatic entrant, the exposure would appear to be a diagnostic exposure, although issues remain about the referral criteria and the competence of the individuals making this assessment for individuals.

For asymptomatic entrants where the x-ray demonstrates TB, there is a medical benefit for this person and societal benefit. If TB is not detected, the benefit to the individual will be social and economic rather than medical (although there is psychological benefit associated with the knowledge of being disease free). The benefit for the society is one of assurance.
Issues remain however around selection criteria, justification and classification of the exposure - is it a medico-legal exposure, screening or diagnostic on the basis that it is preventative and provides potential early diagnosis for the individual?

The justification for the exposure needs to be considered with reference to the subsequent action. This could range from no direct action, even when TB is detected, to treatment or deportation, with possible health consequences for other passengers. Justification should also be influenced by consistency of policy – will TB detection take place at all points of entry into the Member State?

For emigration, where some countries request a recent chest x-ray to safeguard its population, there will always be social and economic benefit to the individual and societal benefit for the country of destination. There will be no societal benefit however for the country of origin, where the justification is undertaken and must conform to national laws.

The presentation raised a number of issues rather than offering solutions and no firm conclusions were raised during the discussion. It was felt that this may prompt further consideration with a view to establishing guidelines.

Professor Piga, from Spain, presented on Health and Employment: Human Rights Aspects.

His presentation did not give rise to an extensive discussion as everyone in the audience accepted the principle of basic human rights. Nevertheless it was very useful to re-introduce the issue of human rights in the specific field of medico-legal exposures, which are not easy to justify in every situation.

Prof. Piga stated that human rights are universal, indivisible and inalienable. They constitute the basis for the Constitution of the European Union. He believed that the effects of globalisation, with increasing inequity, environmental problems, poverty, terrorism and organized criminality, illegal migration movements, and ethnic conflicts, require implementation measures to overcome those situations and to reinforce the ideas of justice and international cooperation.

Today, the concept of health should stress less the absence of disease and handicap and more the value of every human being and his right to contribute to society.
Prof. Piga distinguished between children and adults: for children health in a classical way is the priority, but for adults, the health concept should be enlarged to include the ability to work. For both, there is a need to predict and avoid environmental damage to the health of population, mental health and of course improve and implement curative procedures all over the planet.

Every human activity involves some risk. The risks associated with radiological exposures are factors to be taken into account. The non medical use of ionising radiations should be based on: rational justification, individual indication bearing in mind the circumstances, informed consent, adherence to norms of good practice with written records of the implementation of the procedures and guarantees.

In conclusion, together with respect of the provision of law, ethical guidelines should be respected. Ethics and human rights should be part of the training process of the professionals involved. Understanding the spirit of human rights is more important than blind application of norms.

Dr C Sharp presented on the exposure of workers in diamond mines as a mechanism to deter and detect theft, an unfamiliar subject to most delegates who have no experience of this industry. (Due to copyright issues, his paper cannot be included in these proceedings. See reference at end of this session report)

A history of diamond mining was given. Practices vary between countries regarding the use of x-rays for security and some observers had questioned the ethics of the practice, with concerns raised about human rights etc. This prompted the IAEA to organise a group to assess the justification of these exposures.

The diamond industry is the major national resource for some African countries. Diamonds account for 85% and 27% of export earnings for Botswana and Namibia respectively. Diamond theft therefore has serious economic and social consequences for such countries.

X-ray techniques for detection are more efficient than alternatives and more acceptable to employees than body searching, which is considered to be degrading. The equipment used was mainly modified medical radiological equipment (giving effective doses of 25-37μSv) but modified luggage search equipment had also been used (with effective doses of approximately 17μSv). Recently, specific equipment was developed, delivering an effective dose of only 6μSv. Selection varied between random and systematic, exposures were not always carried out, and dose limits were observed, although as the workers were unaware at each search of their own dose record, the deterrence value remained. Employers believed such exposures were justified, part of the conditions of employment and should be classed as occupational exposures, with dose constraints and dose limits observed. Optimising the practice was considered important.

It was noted that the IAEA advisory group concluded that these exposures were not medico-legal and that FAO, IAEA, ILO, OECD/NEA, PAHO and WHO had concluded that these exposures were not justified.

In the discussion that followed, issues regarding detection versus deterrence were acknowledged. Systems should take into account that most workers are unlikely to be involved in diamond theft. Further consideration of the justification of this practice would require data on detection rates per exposures undertaken. Delegates believed there was some basis for classifying these exposures as occupational.

Reference

Sharp C. “Theft detection (or new light on a girl’s best friend)” In: Faulkner K, Teunen D Eds. Justification in Radiation Protection. *London.* The British Institute of Radiology. 1998; 26-28. ISBN 0 905749 40 5

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General Comments Generated from the Discussions during Sessions I - V

1 According to the Medical Exposure Directive, all individual exposures are supposed to be justified both by the prescriber and by the practitioner, each with respect to their own expertise and area. In cases where a medical doctor is asked by an insurance company, judge, employer etc. to provide advice and/or a conclusion about the physical state of a person, it is likely that x-ray will be indicated to complete the assessment. The prescriber should therefore also justify the X-ray.
However, there are situations where the medical doctor asked for advice, is effectively directed to use x-ray by an employer, judge etc. In those cases, the one who orders the x-ray becomes the prescriber, not legally, but in practice. This situation should be avoided.

2 As was quite clear from the attempts to fill in the questionnaire (even some people who helped to prepare it were not able to answer this questionnaire sufficiently), the network of the radiation protection expert is too limited to cover all the disciplines involved in this medico-legal area. To resolve the various issues and problems that arose, dialogue and co-operation between the different disciplines is needed to develop understanding.

3 On several occasions during the discussions, it seemed that the type of imaging procedure (CT/plain film) and the situation for which the x-ray was to be used was important in the justification process e.g. dental radiography for age determination is useless for certain ages. Existing referral criteria, including the diagnostic tools that should be used as first choice, are available for routine medicine, where a patient has symptoms or there is a strong suspicion for a certain disease. The same counts for diagnostics in health screening programmes. These criteria are not intended for medico-legal purposes. Therefore special referral criteria may be required, which indicate the preferred imaging method for medico-legal exposures, e.g. in the case of age determination, litigation, insurance, (pre)employment.

4 The audience in the symposium and especially the radiation protection experts in this area, should be aware of the fact that their views may differ from those of the individuals directly involved in the exposures. In other words: do our views and values reflect those of the public. The potential for divergence was illustrated by the example of the HIV test in the Netherlands. Another example is the reaction or feelings of workers in small companies who are threatened with unemployment because of financial problems arising because of some chronically or frequently ill co-workers. There is also the ethical problem around the requirements of chest x-ray to screen for TB for immigrants in some Member States. If seen as ethically not justifiable, because only a selective group will be X-rayed, the consequence of not screening could be recurring outbreaks of TB.

The question can also be asked about whether it is justifiable to X-ray all flight passengers (individual dose tens of microsievert) to find small numbers of smugglers. There are differing views on this issue in the general population. Many people say yes because they want to avoid the importation of drugs or weapons.

The conclusion is that although we can decide that some type of exposures are medico-legal, but in deciding as to whether or not they are justifiable, we should take account of the wider social and economic issues that are inherent in this matter. When balancing the pros and cons, a broad range of considerations should form part of the decision-making process.

5 Practical problems for legislation

The question is it ‘preventive medicine’ was asked during the symposium when discussing justification of a number of exposures (e.g. sports medicine). However, the term ‘preventive medicine’ is not used and therefore not defined in the MED, but perhaps it should have been.

6 The MED deals with medical exposures including medico-legal exposures. Medico-legal procedures are defined in the MED, as ‘procedures performed for insurance or legal purposes without a medical indication’. This symposium identified many types of exposures, which could be considered to be medico-legal exposures but would not seem to be covered by this definition. It is clear that consideration should be given to a revision of the term. This may have implications for the scope of the Directive.

7 One issue that was not really discussed during the symposium was that of collective dose. In other words where many individuals receive a very small dose from a certain type of exposure, should this be considered as part of the justification process. It could however be indicative that this issue was hardly considered and didn’t seem to be of interest despite the topic being raised by a number of the speakers and reporters. Perhaps the answer is that these exposures should not be judged collectively but individually.

8 While it is important to remember the value of x-rays in diagnosis or treatment, their importance should not be overstated. It is the patient that should be treated and not the X-ray. X-rays are important tools, but clinical assessment using conventional methods of enquiry and assessment is as important. These ‘tools’ are still the most important in’ diagnosis and often make individual X-rays unnecessary and so unjustified.

9 Future work

Drawing on the outcome of this symposium more work needs to be done:

Firstly the MED should be clarified in a number of ways. It is clear that there is a need for a guidance document, firstly to explain and define terminology used and secondly to provide recommendations for possible national approaches.

Following on from the experiences gained both in the preparation for and during this symposium, it is clear that a further meeting in the near future is required. This would certainly contribute to resolving some of the problems that have been identified and enable further progress to be made in the area.

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KO-57-03-483-EN-C

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