Interactive Web Services for Optimizing Nuclear Medicine

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Abstract. For the Swedish Radiation Safety Authority (SSM) to monitor the development of nuclear medicine in Sweden and to calculate radiation doses to the population, SSM annually collect information on the studies and treatments made. All data are saved in a database for compilation. The data are available on the webpage, www.ssm.se, for each hospital and for all studies from 1999 to 2009. The number of patients and the medium activity are available for adults and for children for each examination or treatment.

On our web site it is also possible to calculate the radiation dose to patients from different procedures through the service "Doskatalogen". Radiation doses were determined for different radiopharmaceuticals for adults, children and adolescents using Monte Carlo simulations. The calculations comply with data from International Commission on Radiological Protection (ICRP).
Unfortunately, the page is in Swedish only, but an informed user can probably easily understand how to obtain the desired information.

An important purpose of disseminating information is to help hospitals with the optimization and modification of practices. The hospitals themselves can individually do a comparative analysis of information obtained through the interactive service on the webpage, www.ssm.se. The search results can be saved as an Excel file on the local computer.

Link to isotope statistics: http://apps.stralsakerhetsmyndigheten.se/isotop/index_nomenu.asp

Link to Doskatalogen: apps.stralsakerhetsmyndigheten.se/lpadoskatalog

Background
There are 32 nuclear medicine departments in Sweden. Four hospitals have Cyclotrons. In 2010 approximately 102 000 examinations and 3000 treatments were performed. The collective dose for adults from diagnostic procedures was calculated to 312 manSv.

KEYWORDS: (nuclear medicine, doskatalogen, isotope statistics, optimization, interactive)

INTRODUCTION

Doskatalogen (a Swedish catalogue of radiation absorbed doses to patients undergoing nuclear medicine procedures) consists of a collection of data sheets that present radiation doses to different organs and tissues, from a large number of radiopharmaceuticals which are used for diagnosis and research. Furthermore the catalogue also provides effective doses (Swedish Radiation Safety Authority [SSM], 2010a), (Swedish Radiation Protection Institute [SSI], 2007).

The primary purpose with the catalogue is to provide radiation protection committees, medical physicists, medical doctors, scientists and other people working in this field with a tool, which is easy to use, for estimating the radiation doses to different patient groups and people in research projects. (SSI, 2007)

The origin of "Doskatalogen" dates back as far as January 1969 when the former Swedish Radiation Protection Institute (since July 2008 Swedish Radiation Safety Authority [SSM]) published a compilation of data sheets under the heading "Radiation dosage from radioactive substances in medical use" (Swedish Radiation Protection Institute [SSI], 1981). During the 1970s several new radiopharmaceuticals were introduced, and the $^{99}Tc^{m}$ usage increased significantly. The launching of

"Doskatalogen" was possible due to several new publications of dose calculations and the newly elaborated MIRD-formalism from the Medical Internal Radiation Dose Committee (MIRD) which made it possible to perform dose calculations to a larger number of organs than before (Snyder, W. S., Ford , M. R., Warner , G. G. & Fisher, H.L. Jr., 1969).

Isotope statistics

Article 12 of the European Directive 97/43/Euratom requires Member States to determine the population radiation dose from medical exposures. (Teunen, D., 1998) Part of the medical radiation exposure is caused by nuclear medicine procedures. All nuclear medicine departments in Sweden are since 2000 obliged by the regulations to report annually to the Swedish Radiation Safety Authority (Strålsäkerhetsmyndighetens föreskrifter (SSMFS 2008:34) om nukleärmedicin, 18 §). Before this, between 1968 and 1990, the Radiation Protection Institute also collected data annually. The reports comprise the type and number of all nuclear medicine examinations and treatments performed during the year, together with the average and maximum activity administered (SSMFS 2008:34, 18 §), (European Commission [EC], 2008). All data are stored in the authority's database for isotope statistics within nuclear medicine which is available as an interactive service at SSM's website. In the data base it is thus possible to search for the activity that is annually administered to patients for diagnostics and therapies in Sweden and make comparative analysis. The user can download the search results as an Excel file. The data available applies to all Swedish hospitals and all studies from 1999 to 2010 and includes both adults and children (SSM, 2011).

METHOD

The dose calculations in "Doskatalogen" were made by using physical parameters in combination with biological parameters. The physical parameters consisted of physical half-life, nuclear decay data and administered activity whereas the biological parameters taken into account were the activity containment in the source organ, the retention of the radionuclide in the source organ, the mass of the target organ and the shape, size, location and structure of the organs (Leide-Svegborn, 2010).

To gain knowledge about the biokinetic data comprehensive studies and compilation of all available literature describing biokinetics for different radiopharmaceuticals were made and complemented with own data when possible. In the development of the biokinetic models the fraction of uptake in different organs and tissues, effective half-life and ways of excretion were taken into account. These data were acquired from imaging and activity quantification with gamma camera, SPECT/CT or PET-camera at several times following administration. Also samples of blood, faeces, urine, tissue and exhalation air taken at several times following administration were studied. (Leide-Svegborn, 2010)

In-house dose calculations, to determine the radiation dose to different organs and tissues as well as the effective dose, where made with an in-house dose calculation program called IDAC. OLINDA (Stabin *et al.,* 2005) was used for independent controls of the calculations. Only human biokinetic data were considered. (Leide-Svegborn, 2010)

The gathering of data for the isotope statistic database is a rather straightforward process since the Swedish Radiation Safety Authority's regulation on nuclear medicine (SSMFS 2008:34, 18 §) states that before the end of April, the license-holder shall submit information to the Swedish Radiation Safety Authority concerning the practice during the preceding calendar year. The report shall cover the number of examinations and treatments performed and the radioactive pharmaceuticals used for each type of examination or treatment as well as the average activities administered. A typical example of such a report is shown in table 1.

Table 1. Example of a completed report template.

Code		Nuclide	Chemical form	Department	Activity		No. of admin.	Admin. Way	Examination purpose	Patient selection (adults/children)
Old 3 digits	SoS 4 digits				Average (MBq)	Max (MBq)				
P80.10	7792	^{11}C	Acetat	Nuclear medicin	400	700	63	i v	Tumor diagnostic	Adult
P80.00	7792	^{18}F	FDG	Nuclear medicin	220	400	1654	i v	Tumor diagnostic	Adult
P80.50	7792	^{18}F	F^- (Fluorid)	Nuclear medicin	185	185	6	i v	Tumor diagnostic	Adult
P80.60	7792	^{68}Ga	DOTATOC	Nuclear medicin	60	185	142	i v	Tumor diagnostic	Adult
(785) 717	7427	^{75}Se	SeHCAT	Nuclear medicin	0,37	0,37	15	p o	Bile salt metabolism	Adult
(791) 796	7781	$^{99}Tc^m$	Antigranulocyt	Nuclear medicin	500	500	9	i v	Abscess, infection	Adult
756	7370	$^{99}Tc^m$	Cardiolite	Nuclear medicin	500	525	169	i v	Parathyreoidea	Adult
750	7513	$^{99}Tc^m$	DMSA	Nuclear medicin	185	185	161	i v	Kidney scintigrafi	Child
736	7312	$^{99}Tc^m$	DTPA-aerosol	Nuclear medicin	50	150	1	inhalation	Lungs, ventilation	Adult

RESULTS

The so called dose sheets have been published in its current formation since 1981 and have since then been revised and complemented with new substances (1982, 1983, 1990, 1993, 1996, 1999, 2003 and 2006). Data for more than 200 substances and radionuclides are included in "Doskatalogen" today (SSM, 2010b). All current dose sheets are since 2002 available online at the webpage of the Swedish Radiation Safety Authority (www.ssm.se).

The project "Doskatalogen" have ever since it began and through the years been supported financially by the research secretariat of the Swedish Radiation Safety Authority. This support has also enabled a perennial engagement within the International Commission on Radiological Protection (ICRP). This engagement – Task Group on Radiation Dose to Patients from Radiopharmaceuticals (Task Group 36) – has resulted in ICRP publication 53 (ICRP, 1988b) with addendum and amendment in ICRP Publication 62 (ICRP, 1993), ICRP Publication 80 (ICRP 1998) and ICRP Publication 106 (ICRP, 2008). (SSM, 2010b)

From the annual reports to the Radiation Safety Authority the collective effective dose can be calculated. The collective effective dose for 2010, from diagnostic nuclear medicine, to adults was 312 manSv. The basic data for this were 96 102 administrations of in total 33 086 GBq. During 2010 there were 5440 pediatric nuclear medicine examinations in Sweden corresponding to 6 % of the adult examinations and an administered activity of 330 GBq. (SSM, 2011). The distribution of all different examination types is illustrated in figure 1. The distribution of the different radiopharmaceuticals is illustrated in figure 2.

In total an activity of 33 416 GBq were administered in diagnostic nuclear medicine in Sweden during 2010. 16 different radioactive elements were used where $^{99}Tc^m$ contributed with 91 % of the total administered activity. Dose conversion factors for different radiopharmaceuticals are taken from "Doskatalogen".

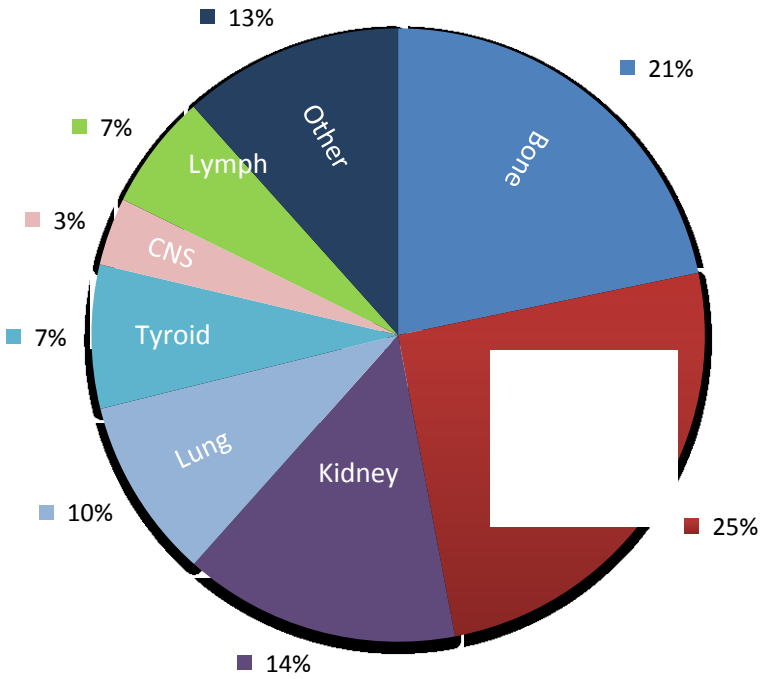

Figure 1. The distribution of examination types for 2010 (101 538 administrations) (SSM, 2011).

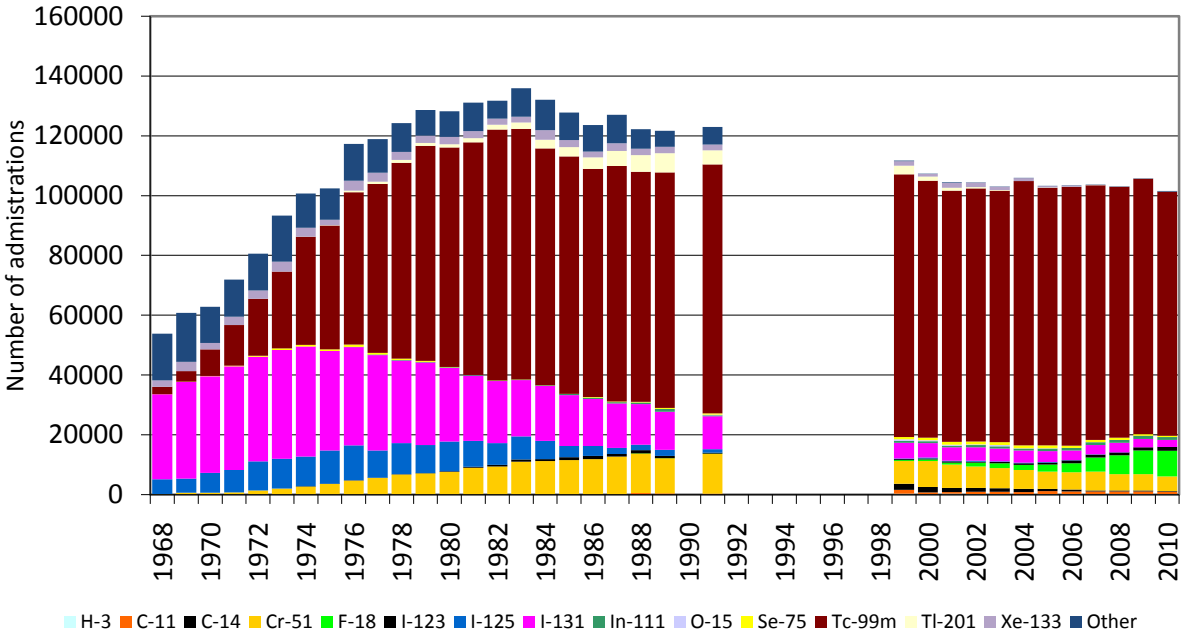

Figure 2. The number of administrations and the distribution of the different radiopharmaceuticals for diagnostics from 1968 to 2010. Between 1992 and 1998 there were no data collected (SSM, 2011).

DISCUSSION

"Doskatalogen" is meant for experts within medicine and research so that radiation doses delivered to patients in a nuclear medicine investigation can be calculated.
There are some limitations with "Doskatalogen". First of all it must be stressed that the dose calculations and the developed models cannot be used for radionuclide therapy since there might be large individual variations in the biokinetics, which might lead to considerable under- or overestimation of the given dose. In general the calculations also only apply for healthy patients but for some substances, where the biokinetics vary substantially with the medical condition, separate models are presented. Biokinetic information specific for children is used to the extent that literature data exist, otherwise adult data is used. Furthermore the radionuclides are assumed to be evenly distributed in the source organ and what is presented is the average dose to the whole source organ (Leide-Svegborn, 2010). Despite the limitations mentioned above "Doskatalogen" works as a very efficient tool for calculating and follow up radiation doses within nuclear medicine.

The plan for 2011-2013 is that the project "Doskatalogen" will continue and in particular regarding the mapping of kinetics and radiation dosage to children. Data for new substances will be added and information for existing substances will be exchanged when new knowledge is available (SSM, 2010c).

Isotope statistics

The reports of isotope statistics can be used to monitor changes in the usage of radiopharmaceuticals, when new radiopharmaceuticals are introduced and when other ceases to be used. Analysis of the reports makes it possible for SSM to consider whether any changes have to be made amongst the examinations that are associated with a prescribed diagnostic reference level. The isotope data base is a useful tool when a nuclear medicine clinic decides to start a new examination method, since they through a simple search in the data base can see if other clinics already perform the examination and if so exchange valuable experience regarding the optimization of the examinations, e.g. the amount of administered activity. The isotope data base can also serve as a tool to compare administered activity for examinations that are not associated with diagnostic reference levels and thus contribute to a progressive optimization work (Jönsson & Richter, 2004).

Another use of the reports is to estimate the emission, from medical services, of radioactive substances to the environment (Jönsson & Richter, 2004).

CONCLUSION

Research and development within nuclear medicine is a continuous process and every year new radiopharmaceuticals are introduced on the market. New radiopharmaceuticals are rapidly taken into use at the hospitals and there is thus a need for information about radiation doses for these radiopharmaceuticals. "Doskatalogen" and the isotope statistic, separately as well as in combination, represent two effective tools for calculating and monitoring the changes in radiation doses in the field.

Collected statistical data are of benefit for both the health care and the SSM. Continuously collecting of data from the health care system has made it possible for SSM to observe changes in the field at an early stage.

The data in "Doskatalogen" have been important to SSM when making adequate assessments of population doses in Sweden.

Within the health care the access to statistical data has made it possible to easy compare the operation modes of different clinics. When introducing new methods and when optimizing existing methods both "Doskatalogen" and the isotope statics plays an important role.

The statistics can also work as a guideline, for those examinations that lack diagnostic reference levels, of what is a relevant choice of activity.

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