Possible radiation injury at Koeberg Nuclear Power Station

Organization of medical care

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Summary

Any injured patient from Koeberg Nuclear Power Station will be treated in the conventional manner as an acute surgical emergency; this has priority over decontamination. The ideal situation is decontamination at Koeberg before ambulance transferral to the Tygerberg Radiation Casualty Facility, but if this is not possible or complete, decontamination can be accomplished by a trained team in the unit. Teamwork is the essence at the place of injury, during transfer, in the decontamination area, in the operating theatre and during the postoperative phase. No surgical management is appropriate or complete without the very necessary guidance and advice from a physicist and the Advisory Group for Radiation Casualties.

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Nuclear energy is one acceptable solution to the world energy crisis and its increased use is projected. Paradoxically, solutions often create problems, in this context, that of possible radioactive contamination. A simplistic explanation of the workings of a nuclear power station is: splitting of the uranium-235 atom (fission), releasing a large quantity of energy in the form of heat, which is employed to convert water into steam to activate turbines, turning an alternator with the generation of electricity as a result. As radioactive byproducts are produced by the fission process, strict containment and control become necessary to avoid contamination. As with other nuclear power stations all over the world, the construction of the Koeberg Nuclear Power Station (KNPS) complies with international safety criteria, but the possibility that an accident could occur always exists and this report addresses the problem of medical management of the casualty contaminated by radioactive material.

The planning of medical care in preparation for a casualty at a nuclear energy plant is at three functional levels: (*i*) immediate emergency care of serious non-radiation injuries which are referred to local institutions as necessary; (*ii*) treatment by local medical care of patients with no or minor injuries complicated by radioactive contamination; and (*iii*) treatment at a specialized hospital unit for the injured contaminated patient, e.g. at Tygerberg Hospital.

In the management of patients in categories (*ii*) and (*iii*) three components must be considered: (*i*) external contamination: the presence of removable radioactive material on clothes, skin or naso-oral cavity; (*ii*) internal contamination due to the ingestion, inhalation and/or absorption of radioactive material into the body; and (*iii*) irradiation: with a sufficiently high dose localized radiation injury and the acute radiation syndrome can occur.

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Emergency protocol

Taking the KNPS as an example, the contaminated patient would be primarily dealt with by the Koeberg medical team. If decontamination is successful the patient is managed locally. If unsuccessful and/or if specific medical management is required for a serious conventional injury or condition, the patient is immediately transferred to Tygerberg Hospital's special Radiation Casualty Facility (TRCF).

If the patient has only been exposed to radiation and the dose received is severe enough to warrant hospital treatment, the patient is transferred to the TRCF for further evaluation and instigation of barrier nursing.

A preconceived plan of action is put into motion. The KNPS duty officer informs the Metro Emergency Control Centre of the number of injured persons and also gives as much detail as possible of the injuries incurred. The Metro Control operator activates the ambulance service and informs the Tygerberg Hospital emergency exchange. The exchange will inform the matron on duty, who will activate the various steps to prepare the TRCF for receiving the patient. The medical superintendent responsible for the TRCF is informed and also the medical team, which consists of a surgeon, an anaesthetist and the members of the Advisory Group for Radiation Casualties (AGRC), comprising an occupational health physician and the heads of the departments of radiotherapy, nuclear medicine, haematology, oncotherapy and medical physics at Tygerberg Hospital. The doctor responsible for Koeberg has special training in dealing with radiation injuries and is supported by health physicists in the handling of radiation casualties. They will support and advise on the management of patients.

Transport of a radiation casualty

Several members of the Metro Rescue Service have been trained in the transport of contaminated casualties and their ambulances are specifically equipped to handle these. The Metro staff wear protective clothing and the ambulance interior is lined with plastic material. The transport of such patients is strictly controlled and monitored.

Tygerberg casualty facility

The TRCF functions as a receiving area and operating theatre to handle the contaminated patient. Control of contamination and radiation, the handling of solid and liquid contaminated

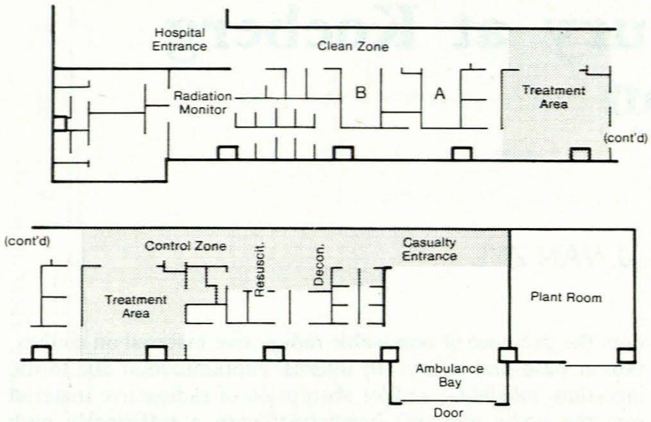

Fig. 1. TRCF layout. The plan must be read from the bottom right to the left followed by the top right to the left to understand the flow of patients. From the ambulance bay the patient moves towards the casualty entrance through to the decontamination and resuscitation area. The operating theatres are situated in the treatment area. The shaded areas are in the control zone and when all conditions have been met the patient is transferred into the clean zone via rooms A or B where all covering clothing, etc. is removed and placed in plastic bags. All patients and staff move through the radiation monitor area before leaving the complex.

material, and the control of personnel are cared for. The TRCF can easily cope with 2 - 6 patients at the same time. Fig. 1 demonstrates the layout of the unit and describes patient flow.

The ambulance staff are allowed to leave the area only after they have been certified free of contamination by the radiation control monitor. The TRCF team members all enter the unit through the hospital entrance into a non-contaminated zone. Entry is strictly controlled and all authorized personnel receive an identification card with their name and function in the unit.

The function of the medical superintendent and his staff is to register the patients on admission and to document all relevant information. To facilitate the flow of patients, especially if several cases require treatment, labelling is performed by the Metro staff at the KNPS.

Handling and treatment protocol

This comprises: (*i*) the resuscitation and stabilization of the injured patient; (*ii*) decontamination of the patient (step (*ii*) may have to be combined with steps (*i*) and (*iii*)); (*iii*) performance of the necessary emergency surgery; (*iv*) initiation of the handling and evaluation of the radiation exposure and restriction of exposure of the medical staff; and (*v*) transfer of the patient as soon as feasible to a conventional hospital ward for observation and treatment.

Resuscitation

The normal procedures are followed either at KNPS or in the resuscitation area of the TRCF. These include maintaining an adequate airway, management of shock, and control of bleeding.

Decontamination

Depending on the urgency of the surgical problem, decontamination may be instituted at KNPS by trained staff. If not, the procedure is performed in the decontamination and treatment areas of the TRCF.

General guidelines for decontaminating patients

Radioactive contamination is seldom life-threatening and therefore urgent medical or surgical treatment has priority. Decontamination is in essence the physical removal of radioactive material from clothes, skin, wounds and body cavities.

In decontamination the aim is to: (*i*) prevent injury caused by the presence of radioactive substances on the body; (*ii*) prevent spread of the contaminant on the skin or internally; (*iii*) safeguard the attending staff against contamination; (*iv*) document the removal of all radioactive material; and (*v*) prevent spread of contamination into the environment.

Staff involved in the decontamination process wear protective clothing, surgical gown, plastic apron, theatre cap and mask, waterproof boots and two pairs of surgical gloves. Each person wears a ring dosimeter and a thermoluminescent dosimeter or film personal dosimeter. Additional protective apparatus may be prescribed by the health physicist in the event of high levels of contamination.

Initial handling of a contaminated patient

The degree and areas of contamination are measured by a monitor held 5 cm above the skin. The findings are recorded on a specific form for this purpose. If urgent medical treatment is necessary the contaminated area is covered with a plastic sheet and the necessary treatment instituted. Smear samples must be taken of the contaminated areas for radio-isotope analysis.

Management of external contamination

For localized superficial contamination of the skin lukewarm soapy water or 10% cetrimide is used to cleanse the skin in a circular movement. The areas are monitored and the procedure is repeated if satisfactory decontamination is not achieved. Persistent areas of skin contamination will require special management. The eyes and the nasal and oral cavities are carefully cleansed and irrigated with normal saline and the patient is instructed to avoid sniffing or swallowing the fluid.

For widespread contamination of the intact skin the patient is undressed and the clothes are placed in marked receptacles. Once the whole body has been monitored, the patient is showered in cool water. This is followed by cleansing of the skin as described above. It is important to protect the integrity of the skin so as to avoid internal contamination.

The contaminated wound

The wound edges are covered with a plastic adhesive material to prevent skin-to-wound contamination. The wound is thoroughly irrigated with normal saline and the fluid removed by suction. The success of the procedure must be determined by repeated monitoring. If it is unsuccessful the surgeon and health physicist must decide on surgical excision. Extensive debridement, sacrificing major vessels, nerves or tendons, is not justifiable. Very careful judgement and consultation with the physicist are necessary before deciding about amputations. The effects of certain radionuclides such as plutonium can be minimized by the use of chelating agents. All debrided tissue is kept for radionuclide analysis. With successful decontamination primary suture of the wound is acceptable but with unsuccessful decontamination secondary suture is employed after further efforts at decontamination.

Handling of internal contamination

It is the responsibility of AGRC members to advise on the removal of radionuclides from the respiratory and gastro-intestinal tracts and the management of radionuclides absorbed into the body. Physical removal by nose blowing, irrigation, mouth washes, removal by swabbing, etc. are the usual methods. Nasal and mouth swabs, urine and faeces are repeatedly monitored where necessary and at times the chest and whole body are scanned. Certain manipulations may become necessary to counter internal contamination, such as the giving of products to lower absorption from the gastro-intestinal tract, limit biological activity and increase excretion rates.

Concluding phase

After decontamination and surgical management the patient is removed to a non-contaminated clean zone. The nurse in the neighbouring clean zone will roll a 1,5 m wide plastic floor covering into the controlled zone next to the table on which the patient lies. A clean trolley will be introduced for transferring the patient from the operating theatre. All personnel in the controlled zone remove their gowns, gloves, etc. and are monitored for residual radioactivity before leaving the area. All covering, clothing, instruments, towels, etc. used in the theatre are labelled for subsequent examination by the physicists and handled according to their recommendations. Before leaving the TRCF all staff are monitored for local contamination.

Postoperative period

This period can be complicated by the manifestation of the acute radiation syndrome; careful monitoring and teamwork are therefore required. The AGRC is especially involved in supporting the surgeon. The many facets of the postoperative phase are beyond the scope of this article.

Kallmann's syndrome with unilateral renal agenesis

A case report

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Summary

A case of Kallmann's syndrome (hypogonadotrophic eunochoidism plus anosmia) in which further investigation revealed the association of unilateral renal agenesis is described. The importance of excretory urography in the investigation of patients with Kallmann's syndrome is stressed.

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The association of underdeveloped genitalia and the absence of olfactory lobes was first described in 1856 in an autopsy report.[1] In 1944 Kallmann described the original syndrome in which reduced luteinizing hormone (LH) and/or reduced follicle-stimulating hormone (FSH) was found in association with hyposmia or anosmia, syndactyly, short fourth metacarpals, colour blindness, nerve deafness and mental retardation.[2] Since the original description other congenital anomalies have been reported in Kallmann's syndrome including harelip,[3] cleft palate,[4] and cryptorchidism.[5]

A patient in whom investigations revealed the rarely observed association of unilateral renal agenesis with Kallman's syndrome is described.

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Case report

A 28-year-old man was referred for investigation of delayed puberty and cryptorchidism. The history revealed the absence of palpable testes, which had occasionally been felt to descend into the inguinal canal. At puberty there had been scanty development of pubic and axillary hair. On specific questioning the patient acknowledged a poor sense of smell, but denied the presence of similar findings or history of infertility in other family members; however, the patient's 12-year-old nephew had impalpable testes. Physical examination showed a tall man (height 1,72 m, span 1,79 m) with a female habitus and sparse facial and axillary hair. The cardiovascular, respiratory and gastro-intestinal systems were normal. CNS examination showed a man with normal intellect, normal hearing but an impaired sense of smell on quantitative testing. Examination of the urogenital system revealed minimal pubic hair, an infantile penis and bilateral impalpable testes.

The presence of hypogonadism, cryptorchidism plus anosmia were highly suggestive of Kallmann's syndrome. This diagnosis was supported by the findings of low serum LH, FSH and testosterone levels on three separate occasions, in the presence of normal serum biochemistry and hormone profiles (Table I). Combined pituitary testing with Actrapid insulin (Novo) 0,15 μg/kg,