Medical Management of Radiation Accidents: Management of the Acute Radiation Syndrome

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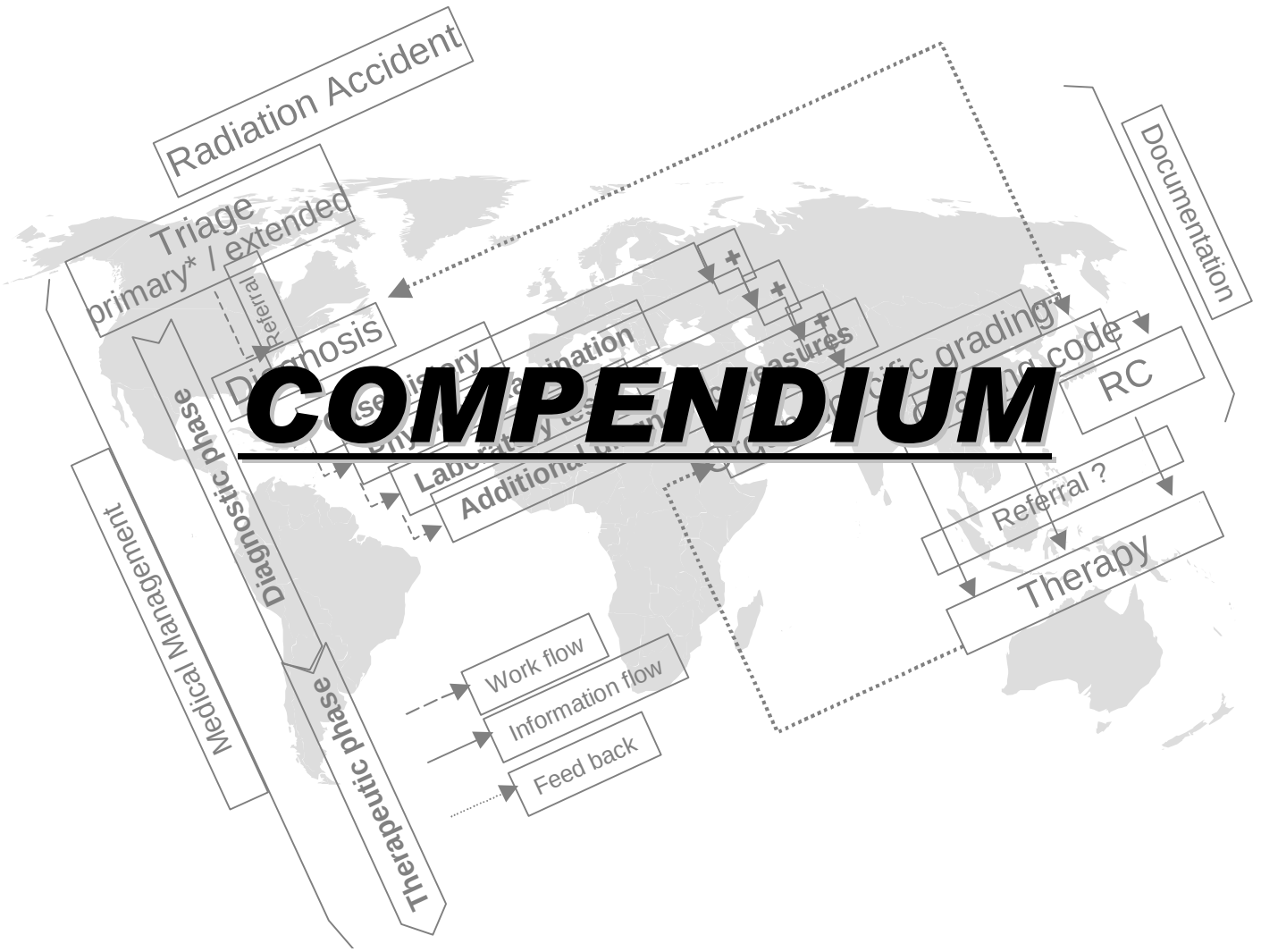
MEDICAL MANAGEMENT OF RADIATION ACCIDENTS



COMPENDIUM

MANUAL ON THE ACUTE RADIATION SYNDROME

BIR Published by The British Institute of Radiology

Introductory remarks

In the case of accidental or suspected exposure of humans to external, penetrating total body irradiation (TBI) or large volume partial body irradiation (PBI), immediate and specialised care is required. Prior to the initiation of appropriate therapeutic procedures it is necessary to assess the state and probable outcome of radiation accident victims in the shortest time possible. To organise the medical management of these patients appropriately it is necessary to anticipate the clinical course and to decide what needs to be examined and what should be documented. Co-ordination of the multiple tasks required in such an emergency might be difficult. Therefore this compendium is designed to guide the medical management of persons accidentally exposed to ionising radiation.

This compendium is not meant to replace the main document[1]. It is recommended that it be used in combination with the main document, where the scientific and pathophysiological background for an understanding of the complex interactions of the acute radiation syndrome (ARS) are provided in more detail.

This compendium is a useful supplement, providing short definitions, keywords and brief overviews in the form of figures or tables on the following subjects:

- Definition of **acute radiation syndrome** (ARS)
- The most **critical organ systems** in which effects can be expected after acute exposure to ionising radiation
- Description and terminology of the **response category (RC) concept**
- Procedures for **establishing** the organ specific **grading**, the **grading code** and the corresponding **RC**
- List of observable **signs and symptoms** reflecting the clinical manifestation of ARS and the severity of damage
- **Critical phases** in the medical management of ARS (**triage**, **diagnostic steps** and recommended **frequency of examination**)
- **Therapeutic principles**
- **Therapeutic and institutional levels of care** according to the RC concept

At the end of this compendium a "Patient Accompanying Documentation Sheet" (**PADS**) is provided, which will aid the essential task of documenting systematically a patient's condition after a radiation accident.

Acute radiation syndrome

The ARS is a composite of characteristic signs, symptoms and health impairments after TBI or large volume PBI. These develop as a result of damage to early reacting organ systems and are manifest within 60 days. A prodromal phase (first week after exposure) can be distinguished from a manifest illness phase.

Critical organ systems

The most critical organ systems in which effects can be expected after acute exposure to ionising radiation are the:

- Neurovascular system (N)
- Haematopoietic system (H)
- Cutaneous system (C)
- Gastrointestinal system (G)

[1]Fliedner TM, Friesecke I, Beyrer K. Medical management of radiation accidents. Manual on the acute radiation syndrome. London: The British Institute of Radiology, 2001.

RC concept

Description

The aim of the RC approach is to assess the damage to the critical organ systems as a function of time after radiation exposure using indicators of effect, *i.e.* observable clinical signs and symptoms. These reflect the clinical manifestation and the severity of the damage to the accident victim. This assessment will be the basis for assigning a patient to different RCs, each of which requires specific therapeutic strategies.

Grading

Describes the extent of damage to a specific organ system by assessing relevant symptoms that manifest in the course of ARS, using semi-quantitative criteria (see below).

Grading code

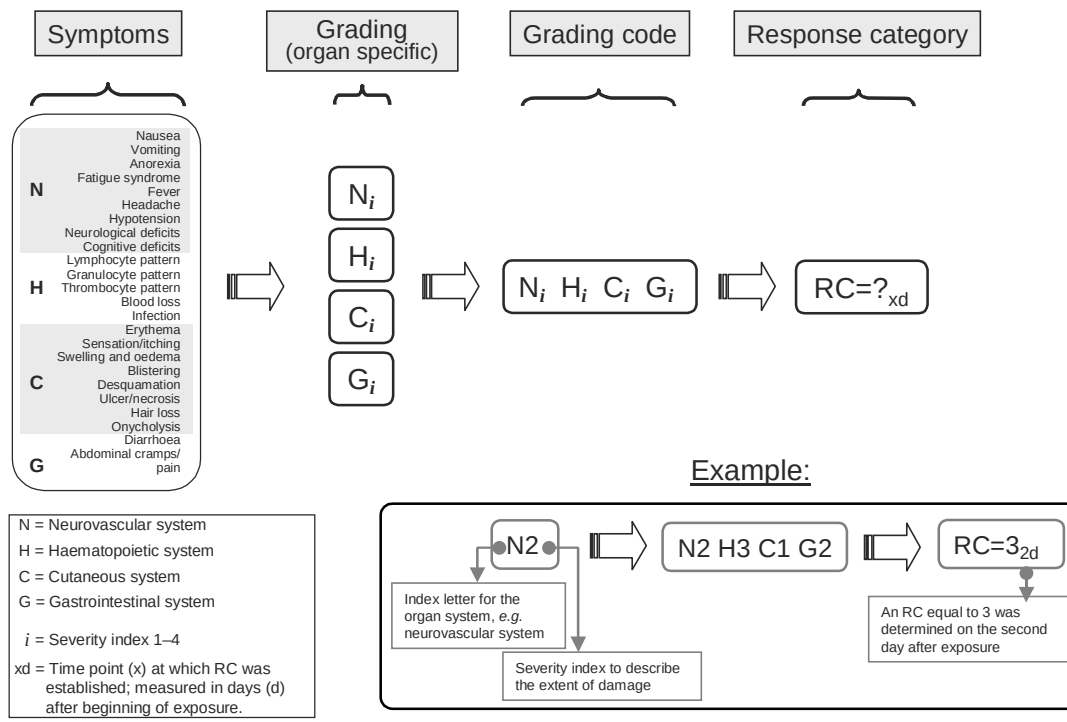
Term resulting from the combination of the organ specific grading, providing a weighted description of the major radiation reactions in the victim.

Response category (RC)

Interpretation of the overall state and outcome of the radiation accident victim, based on the grading and grading code. This is useful as a basis for decision-making in the medical management as it assigns patients to different therapeutic and institutional levels of care. It is also meant to facilitate the comparison of intra- and inter-individual data on a national as well as an international level. An initial RC resulting from the prodromal phase can be distinguished from an epicritic RC, which summarises the clinical course retrospectively at day 60.

Terminology

The following figure depicts the terminology used for the RC concept.



Establishing grading, grading code and RC

The steps for establishing the organ specific grading, the grading code and the corresponding RC are:

1. Assess each observable symptom according to the list "Signs and symptoms" (see below).
2. Take the maximum of the degree of severity (1–4) found in any of the organ specific symptoms to determine the damage to the individual organ system (maximum approach) and attach this number as an index to the initial of the organ system.
3. Proceed in this way for all the critical organ systems.
4. Combine each organ specific grading to the grading code.
5. The highest organ specific severity index of the grading code determines the RC at a certain time point.
6. Repeat steps 1–5 at certain intervals (see "Frequency of examination" below).

Enter all the above information directly onto PADS (see second part of the Compendium).

Signs and symptoms

The observable signs and symptoms reflecting the clinical manifestation of ARS and the semiquantitative criteria for assessing the degree of severity of these symptoms in a standardised way are listed below.

Neurovascular system

Symptom	Degree 1	Degree 2	Degree 3	Degree 4
		N		
Nausea	mild	tolerable	intense	excruciating
Vomiting	occasional, 1/d	intermittent, 2–5/d	persistent, 6–10/d	refractory >10/d or parenteral nutrition
Anorexia	able to eat, reasonable intake	significantly decreased intake but able to eat	no significant intake	parenteral nutrition
Fatigue syndrome[a]	able to work or perform normal activity	interferes with work or normal activity	needs some assistance for self-care	prevents daily activity
Fever	<38 °C	38–40 °C	>40 °C for less than 24 h	>40 °C for more than 24 h or accompanied by hypotension
Headache	minimal	tolerable	intense	excruciating
Hypotension	HR>100/BP>100/70	BP<100/70	BP<90/60; transient	BP<80/?; persistent
Neurological deficits[b]	barely detectable neurological deficit; able to perform normal activity	easily detectable neurological deficit, no significant interference with normal activity	prominent neurological deficit, significant interference with normal activity	life threatening neurological signs, loss of consciousness
Cognitive deficits	minor loss of memory, reasoning and/or judgement	moderate loss of memory, reasoning and/or judgement	major intellectual impairment since accident	complete memory loss and/or incapable of rational thought

HR, heart rate; BP, blood pressure.

[a] Fatigue: self-recognised state of overwhelming, sustained exhaustion and decreased capacity for physical and mental work—not relieved by rest. Typical descriptions are drained, finished off, lethargic, beaten, exhausted or worn out, prostration, drowsiness. Components are physical, cognitive, emotional/affective.

[b] Neurological deficits: reflex status including reflexes of the eye, ophthalmoscopy (oedema of papilla), fainting, dizziness, ataxia and other motor signs, sensory signs.

Haematopoietic system

Symptom	Degree 1	Degree 2	Degree 3	Degree 4
		H		
Lymphocyte changes[a]	$\geq 1.5 \times 10^9$/l	$(<1.5–1) \times 10^9$/l	$(<1–0.5) \times 10^9$/l	$<0.5 \times 10^9$/l
Granulocyte changes[b]	$\geq 2 \times 10^9$/l	$(<2–1) \times 10^9$/l	$(0.5–1) \times 10^9$/l	$<0.5 \times 10^9$/l or initial granulocytosis
Thrombocyte changes[c]	$\geq 100 \times 10^9$/l	$(<100–50) \times 10^9$/l	$(<50–20) \times 10^9$/l	$<20 \times 10^9$/l
Infection	local; no antibiotic therapy required	local; only local antibiotic therapy required	systemic; p.o. antibiotic treatment sufficient	sepsis; i.v. antibiotics necessary
Blood loss	petechiae; easy bruising; normal Hb	mild blood loss with <10% decrease in Hb	gross blood loss with 10–20% decrease in Hb	spontaneous bleeding or blood loss with >20% decrease in Hb

[a]Reference value: $(1.5–4) \times 10^9$/l.
[b]Reference value: $(4–9) \times 10^9$/l.
[c]Reference value: $(140–400) \times 10^9$/l.

Cutaneous system

Symptom	Degree 1	Degree 2	Degree 3	Degree 4
		C		
Erythema[a]	minimal and transient	moderate; isolated patches <10 cm^2; not more than 10% of body surface (BS)	marked; isolated patches or confluent; 10–40% of BS	Severe[b]; isolated patches or confluent; >40% of BS; erythroderma
Sensation/itching	pruritus	slight and intermittent pain	moderate and persist pain	severe and persistent pain
Swelling/oedema	present; asymptomatic	symptomatic; tension	secondary dysfunction	total dysfunction
Blistering	rare, with sterile fluid	rare, with haemorrhage	bullae with sterile fluid	bullae with haemorrhage
Desquamation	absent	patchy dry	patchy moist	confluent moist
Ulcer/necrosis	epidermal only	dermal	subcutaneous	muscle/bone involvement
Hair loss	thinning, not striking	patchy, visible	complete and most likely reversible	complete and most likely irreversible
Onycholysis	absent	partial	Ø	complete

Changes in the skin pigmentation may also occur. However, given the lack of reference data describing depigmentation or hyperpigmentation, this symptom is not included in the grading. Nevertheless it should be recorded systematically, as it may be helpful in future radiation accidents.
Ø, not defined.
[a]The extent of the skin area affected is decisive and should be documented for all skin changes.
[b]Only for penetrating irradiation.

Gastrointestinal system

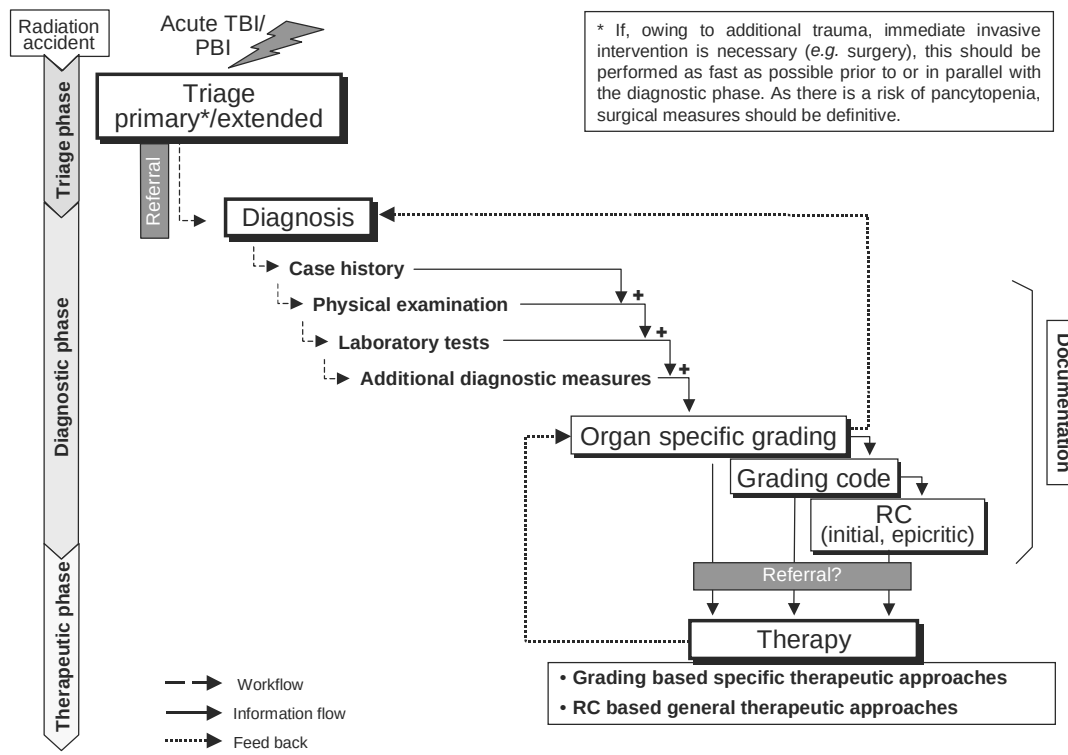
Symptom	Degree 1	Degree 2	Degree 3	Degree 4
G				
Diarrhoea				
Frequency	2–3 stools/d	4–6 stools/d	7–9 stools/d	≥10 stools/d; refractory diarrhoea
Consistency	bulky	loose	sloppy	watery
Mucosal loss/d	intermittent	intermittent with large amount	persistent	persistent with large amount
Bleeding/d	occult	intermittent	persistent	gross haemorrhage
Abdominal cramps/pain	minimal	tolerable	intense	excruciating

Critical phases in the ARS

Four essential issues must be considered in patient management after a radiation accident:

- the assessment of the severity of damage
- the decision on the kind of hospital
- the provision of appropriate therapeutic interventions
- the evaluation of the patient's prognosis

The following figure shows the "workflow" that will guide the management of the radiation accident victim.



Triage

Triage is an important initial phase after the radiation accident.
Primary triage (as known from any other emergency situation)

- check vital signs and symptoms
- check necessity of surgical intervention

Extended triage

- perform a preliminary assessment of radiation induced effects, which will determine subsequent treatment options
- check the necessity of decontamination/decorporation
- referral to primary care institution

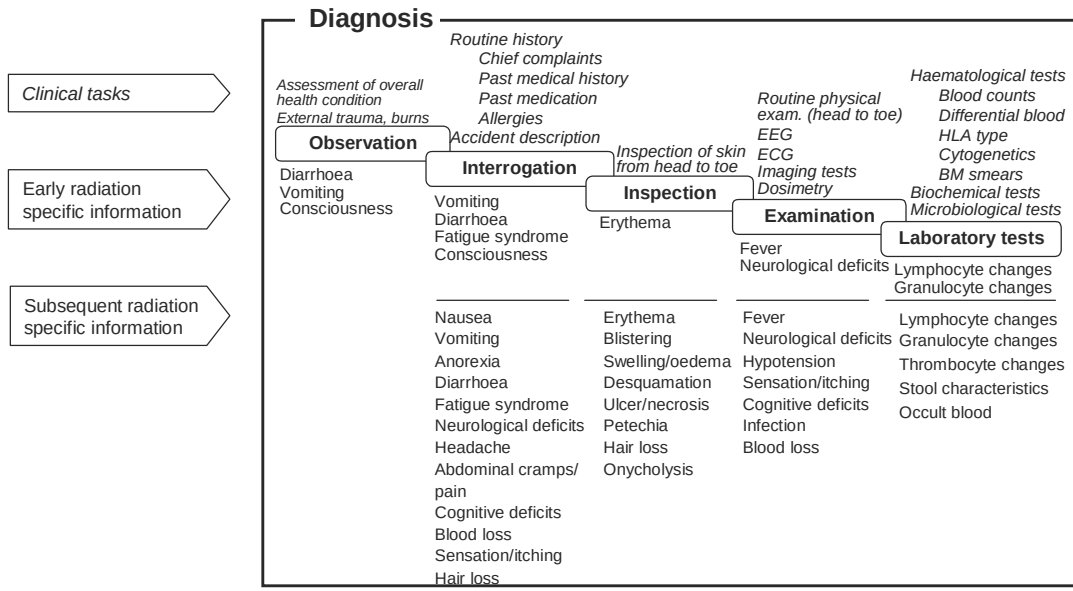
Diagnosis

In the diagnostic phase information is collected which is necessary for the assessment of the patient's health status as a function of time after exposure to ionising radiation. Usually the diagnostic phase is composed of:

- Observation
- Interrogation
- Inspection
- Examination
- Laboratory tests

Observation, interrogation and inspection are easy to perform. All provide good information on the medical history of the patient as well as on the nature of the accident. Physical examinations and laboratory tests (including additional diagnostic measures) complete the diagnostic phase and allow the grading, grading code and RC to be obtained.

The following figure summarises the different medical tasks to be performed.



Observation

By simply observing the patient, valuable information is gained on the general physical state as well as the presence and extent of any external trauma or burns that require special attention. Early radiation specific information can be gained on symptoms such as vomiting, diarrhoea and consciousness.

Interrogation

Interrogation is one of the major sources of information. By taking a detailed history the doctor learns about the patient's main current complaints as well as his role in the accident and his past medical history, which might influence the clinical course. In addition, the patient's answers enable his intellectual capacity and cognitive function to be assessed.

Early radiation specific information can be gained on symptoms such as vomiting, diarrhoea, consciousness and fatigue but now—in contrast to the doctor observing them—from the patient's viewpoint.

A witness statement might provide reliable information during this phase. Furthermore, a schematic drawing of the patient's location during the accident might prove useful.

Inspection

A thorough inspection of the entire integument from head to toe is necessary, both to detect early reactions of the skin and to provide a baseline to help recognise a delayed onset of cutaneous signs. In addition to a detailed written description, colour photography is extremely helpful in documenting the findings and their changes over time.

Examination

A thorough physical examination provides valuable information on all organ systems, this being necessary to complete the clinical picture of the patient. Again, this information constitutes a baseline inventory for the assessment and interpretation of future developments in the patient's course.

Using basic technical equipment, blood pressure, temperature, neurologic status, etc. can be assessed quantitatively and incorporated into the RC concept.

Laboratory tests

Many laboratory tests are routinely used to supplement and verify diagnosis. Blood counts are extremely important as routine screening for the early grading. In addition, blood samples should be taken for the following tests:

- HLA typing, in case transplantation therapy may be required (within 24 h, hold at 4 °C)
- Cytogenetic tests: indicators of effect and repair for the assessment of genotoxic changes
- Lymphocyte tests: immune status
- Reticulocyte count: reliable quantitative marker to monitor haematopoietic reconstitution and the efficacy of therapy (will be of importance in the future as automated reticulocyte counting machines become used more frequently)

Blood smears and bone marrow examinations have to be performed to detect mitotically connected abnormalities and to determine the pattern of degeneration and the onset of haematopoietic regeneration, respectively. Also, stem cell tests are helpful for a quantitative assessment of stem cells and the frequency of stem cell damage.

Interleukin 8 (IL-8), procalcitonin (PCT) and C-reactive protein (CRP) should be assessed in addition to microbiological colonisation tests from blood cultures, other body fluids or the skin to detect early signs of infections and to act accordingly.

Electrolyte loss and fluid loss need to be assessed for possible replacement. In addition, functional tests of liver, kidney, metabolism, the endocrine system, etc. should be performed. As exposure to TBI or large volume PBI will most likely also affect the reproductive system, semen analysis should be done (if feasible) as well as laboratory tests on luteinising hormone (LH), follicle stimulating hormone (FSH), testosterone and prolactin.

Additional diagnostic measures

Additional information can be obtained by different imaging studies, which can be used either to evaluate the patient's present state or to establish reference information for follow-up examinations.

- chest X-ray (status of the lung, early detection of ARDS, etc.)
- abdominal X-ray (*e.g.* in case of suspected ileus)

If available, CT or MRI is useful in assessing the extent of oedema, inflammatory reactions, necrosis/atrophy or the depth of ulcers. Furthermore, MRI might be helpful in detecting gut fistulas. Ultrasound is useful in the assessment of the organs in the abdominal cavity, as well as in the detection of skin thickness, density and depth of ulcers using 7.5 MHz and higher. Also thermography, capillary microscopy, profilometry, bone scintigraphy and histology are known to be useful in the diagnosis of skin lesions.

Electroencephalography (EEG) is valuable in the assessment of changes in brain electrical activity, as slowing of the EEG waves is an indicator of high dose exposure.

Electrocardiography (ECG), part of the routine diagnostic inventory, provides basic information on the cardiovascular system.

The results of physical and biological dosimetry are meaningful for the general assessment of the clinical course and the probability of late effects. They will not be of much help in the initial clinical management of a patient as the results will usually not be available until several days after exposure. For biological dosimetry it is important to obtain relevant material for examination (*e.g.* blood samples for chromosomal analysis) as soon as practicable after the accident.

Frequency of examination

According to the RC approach, the first examination should be done as soon as possible after the radiation accident. It will give critical information on the patient's further clinical course. Each repeated examination will improve the reliability of the diagnosis (RC). However, the frequency of examination will depend on the severity of damage and the individual clinical performance of the patient (see table below).

High technology diagnostic methods are not necessary in the first instance for assessing the radiation induced damage to a patient. Therefore, they are not taken into account in the following recommendations, given as a rule of thumb for the RC concept.

RC 1, mild damage	Complete system review every 24 h (for 6 days). Thereafter once weekly. Final assessment at day 60 post exposure.
RC 2, moderate damage	Without clinical complications such as bleeding, infections, etc., complete system review every 24 h (for 6 days). Thereafter once weekly. With clinical complications, complete system review every 12 h (until stabilisation of symptoms). Thereafter once weekly. Final assessment at day 60 post exposure.

RC 3, severe damage	Without clinical complications such as bleeding, infections, unconsciousness, etc., complete system review every 12 h (for about 6 days). Thereafter once daily (up to day 30). Only if signs of recovery are seen can the intervals be extended (examination once weekly). With clinical complications, complete system review every 6 h (until stabilisation of symptoms). Thereafter proceed as described for RC 3 without clinical complications. Final assessment at day 60 post exposure.
RC 4, serious damage	Complete system review every 6 h (for about 3 days, in case of uncertainties or clinical complications for about 6 days). Thereafter examination once daily. Only if signs of recovery can be seen and no additional complications arise can the intervals be extended (examination every 2 or 3 days or once weekly). Final assessment at day 60 post exposure.

Therapeutic principles

In accordance with the grading, the grading code and corresponding RCs, the following treatment concepts can be suggested. They are explained in more detail below.

- Supportive care
- Substitution (blood component therapy)
- Stimulation (growth factor therapy)
- Stem cell transplantation (SCT)
- Surgery

However, therapeutic measures should be adapted to the state of health of the patient and in particular to the extent of damage to different organs and organ systems by radiation exposure. Furthermore, individual contraindications and possible side effects have to be taken in account when prescribing any of the following medication.

Supportive care

Anti-emetic therapy

Drug therapy with anti-emetics of low effectiveness (such as antihistamines) or high effectiveness (such as 5-HT_3-antagonists, dopamine-D2-antagonists).

If this is not sufficiently effective, glucocorticoids might be indicated (caveat: check contraindications). Furthermore, it is possible to combine these with neuroleptics (*e.g.* butyrophenone, phenothiazine, benzodiazepines).

Analgesic therapy (in accordance to WHO schemes)

Level I: non-steroidal anti-inflammatory drugs (except aspirin).
Level II: low effect opiates.
Level III: high effect opiates.
When level III opiates are not sufficiently effective it might be useful to combine them with corticosteroids and neuroleptics.

Brain oedema therapy

Medication with corticosteroids (dexamethasone).
Low dose scheme (20–40 mg initially, followed by daily doses of 2–4 mg)
High dose scheme (40–100 mg initially, followed by slow dose reduction)
In addition mannitol (20%) and diuretic drugs i.v.
Artificial ventilation as well as neurosurgical intervention might be required.

Adapted nutrition (including electrolyte and fluid replacement)

Diet adaptation (small portions).

Hypercaloric food.

Parenteral nutrition (peripheral or central i.v. application of prefabricated complete solutions, or individual schemes), including adequate substitution of vitamins and trace elements.

Electrolyte and fluid replacement according to laboratory assessed loss.

Antibiotic treatment

Specific antibiotic therapy as early as possible, according to microbiological tests.

If not available: broad spectrum penicillin plus third generation cephalosporin or monotherapy with one of the latest carbapenem antibiotics (caveat: check for most recent recommendations).

In case of life-threatening exposure, additional gastrointestinal decontamination according to common schemes.

In febrile patients not responding to antibiotics, fungal infection must be suspected, which requires systemic antifungal therapy.

In addition, antiviral therapy might be indicated for herpes simplex or cytomegalovirus infection.

Furthermore, for severely injured patients the use of a protective environment has been described as being effective.

Skin treatment

In the prodromal stage basic therapy is usually required with linoleic creams or lotio alba, as well as non-atrophogenic steroids and antihistamines.

Later it is important to apply topical or systemic steroids, tetrachlorodecaoxide (TCDO), thrombocytic growth factors, hydrocolloid dressings, antibiotic prophylaxis and analgesics.

In the chronic or late stage of cutaneous symptoms, retinoids, interferon gamma, superoxide dismutase, pentoxifylline and alpha-tocopherol might have to be applied.

Further approaches

According to the patient's general state, physical exercises, occupational therapy, etc. to help overcome fatigue.

Psychological and educational interventions, occupational therapy and physiotherapy might be helpful in the treatment of impaired cognitive functions.

In the case of seizures, anticonvulsive drugs (oral or i.v., occasional or permanent).

In the case of hypotension, initially the application of sympathomimetics might be helpful (but check for the underlying cause).

In the case of abdominal cramps, analgesic treatment can be combined with antispasmodics.

In general, for the acute and subacute phases, treatment is directed against neurohormonal mediators, and loperamide, which has both antimotility and antisecretory activity, seems to be the drug of choice.

Furthermore, attempts should be made to protect the gut mocosa and prevent entry of either endogenous and/or exogenous agents. To this end, elementary diets, with particular reference to glutamine, cholestyramine to chelate bile acids, probiotics and sulcralfate, may be of use.

Substitution

In immune compromised patients, blood component treatment might be followed by graft *versus* host disease. To prevent this, leukocyte depletion is recommended for blood component therapy (filtration or irradiation).

Thrombocyte concentrates

Platelet substitution is recommended on the basis of the patient's individual medical situation and threshold values. Substitution is indicated if:

- Close monitoring possible, no other complications, no bleeding: threshold for substitution is 10×10^9/l
- Close monitoring not possible, increased risk or manifest bleeding: threshold for substitution is 20×10^9/l
- Additional trauma, surgery, mass transfusions, cerebral oedema: threshold for substitution is 50×10^9/l

Granulocyte concentrates

Usually neither indicated nor efficient. Might be useful only in the case of septic ulcerations.

Highly related to increased risk of cytomegalovirus infection.

Erythrocyte concentrates

Anaemia is not usually a direct effect of irradiation. Without strict indication there is a risk of overtransfusion, which might negatively influence the regeneration of the erythropoietic system.

Transfusion required if Hb < 10 g/dl in patients with known coronary heart disease, or clinical situation with decreased intracerebral perfusion.

Stimulation

The field of cytokine stimulation is changing rapidly. To date several growth factors are in clinical trial and use, respectively. The most effective growth factors are granulocyte-colony stimulating factor (G-CSF), granulocyte–macrophage colony stimulating factor (GM-CSF) and thrombopoetin (TPO). Several combinations of these agents have been tested in clinical trials, but a final recommendation cannot be given, although the combination of TPO and G-CSF seems to be promising. However, TPO should be administered very early after the exposure, *i.e.* within 24 h, to be most effective.

In addition to haematopoietic cytokines, several growth factors appear to promote the restoration of the gastrointestinal epithelium and/or the surrounding tissue. IL-11 and keratinocyte growth factor (KGF) are currently being investigated. However, growth factor therapy for the gastrointestinal syndrome is not yet in clinical use and much work remains to be carried out to show that it yields clear therapeutic benefits for radiation accident victims.

Stem cell transplantation

If it turns out that spontaneous haematopoietic recovery is impossible, stem cell transplantation must be considered, the effectiveness and feasibility of which depends on the individual situation. Sources of haematopoietic stem cells are:

1. Bone marrow
2. Peripheral blood
3. Umbilical cord blood

In a radiation accident situation, most likely allogeneic stem cell transplantation (SCT) will take place.

Stem cells should preferably be obtained in the following order of priority:

1. From a human leukocyte antigen (HLA) identical sibling
2. From other HLA-identical members of the family
3. From an HLA-identical unrelated donor

The SCT has to follow the institutional protocols of the hospital and there should be interdisciplinary collaboration with the transplantation unit.

Surgery

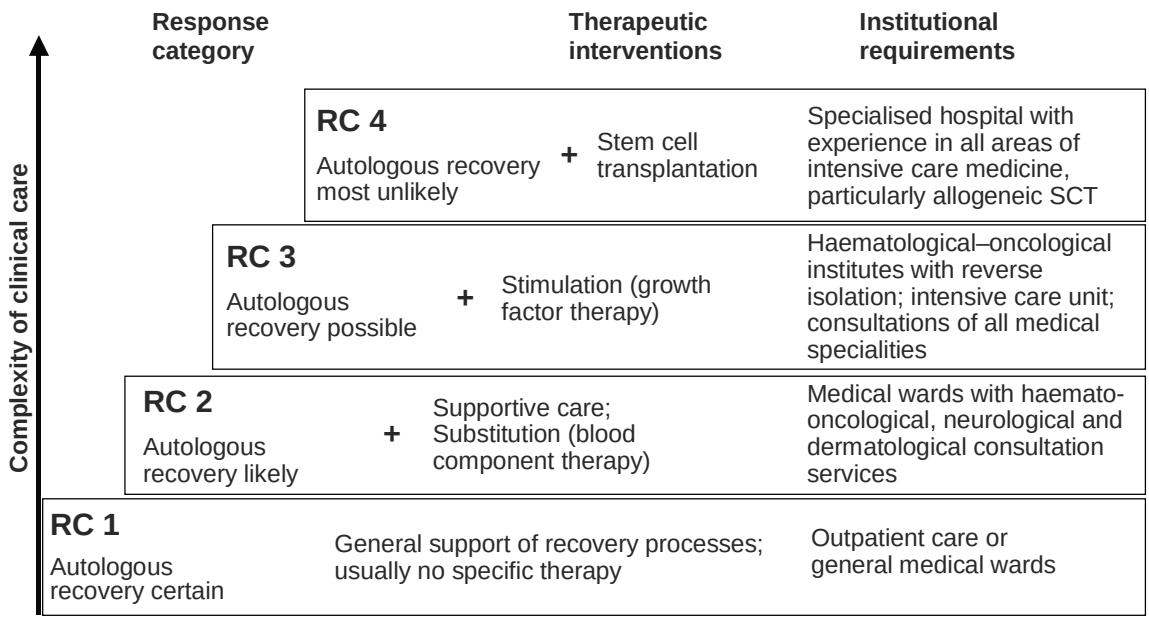
When surgical interventions are required, they have to follow the specific rules for surgery of an irradiated patient. Owing to the risk of pancytopenia, surgical interventions should be carried out as early as possible after the irradiation, or at a time when the risk of bleeding or infection can be controlled.

With regard to the treatment of skin lesions, puncture of blisters, excision of ulcers or fibrotic tissue, primary wound closure, split or full thickness skin grafts or vascularised flaps may be indicated. If basal and squamous cell carcinomas occur in the late effect phase after exposure to ionising radiation, they should be excised.

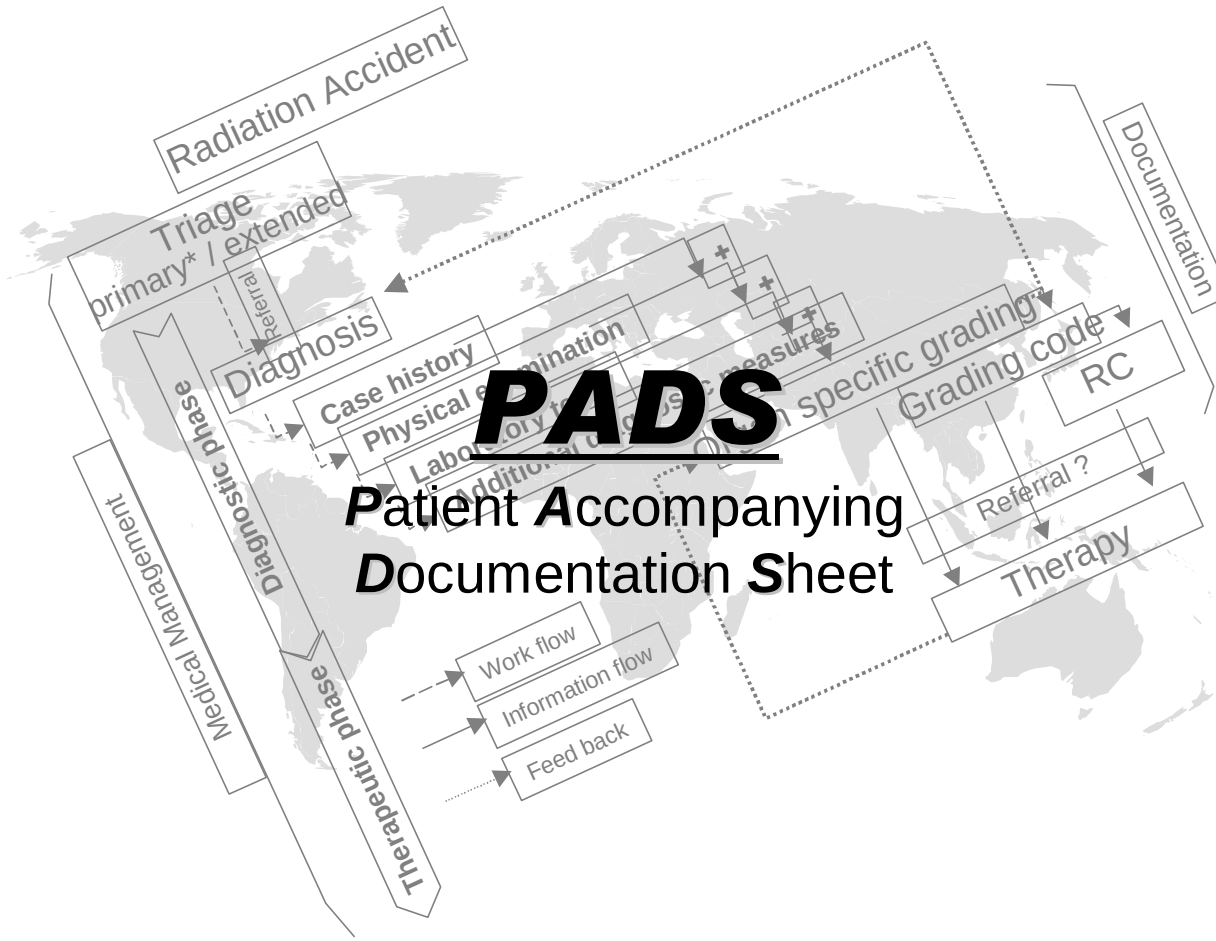
Furthermore, surgical interventions according to common rules should be considered for the treatment of ileus, gut fistulas, or—if at all possible—brain oedema.

Therapeutic and institutional levels of care

The following figure gives a synopsis of the RC-dependent therapeutic and institutional levels of care for radiation accident victims.



MEDICAL MANAGEMENT OF RADIATION ACCIDENTS



PADS

***P**atient **A**ccompanying*
***D**ocumentation **S**heet*

MANUAL ON THE ACUTE RADIATION SYNDROME

Accident Information
(As this information is the same for all victims, this section can be copied and attached to the PADS of the other patients)

Accident location: _____

Address: _____

City: _____ State: _____ Zip: _____

Telephone: _____ Fax: _____

Proprietor of the radiation source: _____

Beginning of accident (date and time): _____

End of accident (date and time): _____

Number of persons involved: _____

General accident description: _____

Source of irradiation:

- ☐ Reactor accident
- ☐ Nuclear explosion
- ☐ Sealed source
- ☐ Unsealed source
- ☐ Critical chain reaction
- ☐ Other: _____

Additional comments: _____

Patient ID:	**Date of admission:**

General Patient Data

Patient name (last, first, m.): _____

Address: _____

City: _____ State: _____ Zip: _____

Telephone: _____ Fax: _____

Date of birth: _____ Sex: ☐ Male ☐ Female

General Information on the Investigator

Institution involved in the patient care: ☐ Primary care institution ☐ Specialised hospital

Address: _____

City: _____ State: _____ Zip: _____

Telephone: _____ Fax: _____

Investigator (name): _____

Status: ☐ Physician ☐ Medical personnel ☐ Other:

Personal Exposure Information

Beginning of personal exposure (date and time): _____

End of personal exposure (date and time): _____

(Occupational) Activity at the time of the accident: _____

Individual accident description: _____

(A drawing might be helpful)

Dose Estimates (fill in as soon as results are available)

Evaluation of average TBI:	Date:		Method:		Dose (Gy):
Evaluation of local doses:	Date:		Method:		Dose (Gy):
Other:	Date:		Method:		Dose (Gy):

Kind of radiation: ☐ α-particles ☐ β-emitters ☐ γ-source ☐ X-rays ☐ Other:

Known/suspected: ☐ Contamination ☐ Incorporation

Pre-accident History (to be elaborated as usual covering all organ systems!)

Information of special interest concerning the ARS (uk = unknown)

CNS

Psychiatric disorders: ☐ uk ☐ no ☐ yes, if yes, please specify: _____

Neurological disorders: ☐ uk ☐ no ☐ yes, if yes, please specify: _____

Neurovascular disorders: ☐ uk ☐ no ☐ yes, if yes, please specify: _____

Malignancies: ☐ uk ☐ no ☐ yes if yes, please specify: _____

Others: ☐ uk ☐ no ☐ yes if yes, please specify: _____

Haematopoietic system

Leukaemia: ☐ uk ☐ no ☐ yes, if yes, please specify: _____

MDS: ☐ uk ☐ no ☐ yes, if yes, please specify: _____

Other malignancies: ☐ uk ☐ no ☐ yes, if yes, please specify: _____

Others: ☐ uk ☐ no ☐ yes, if yes, please specify: _____

Skin

Scars: ☐ uk ☐ no ☐ yes, if yes, please specify: _____

Rash: ☐ uk ☐ no ☐ yes, if yes, please specify: _____

Mycotic diseases: ☐ uk ☐ no ☐ yes, if yes, please specify: _____

Allergic diseases: ☐ uk ☐ no ☐ yes, if yes, please specify: _____

Malignancies: ☐ uk ☐ no ☐ yes, if yes, please specify: _____

Others: ☐ uk ☐ no ☐ yes if yes, please specify: _____

GIT

Related diseases: ☐ uk ☐ no ☐ yes, if yes, please specify: _____

Malignancies: ☐ uk ☐ no ☐ yes, if yes, please specify: _____

Others: ☐ uk ☐ no ☐ yes, if yes, please specify: _____

Additional Past Health Information (including date of first diagnosis)

Other organ systems

Lung: _____

Heart: _____

Vascular system: _____

Liver: _____

Bone and skeleton: _____

Endocrine system: _____

Eyes: _____

Others: _____

Malignancies _____

Allergies _____

Past hospitalisations _____

Habits

Tobacco: _____

Alcohol: _____

Others: _____

Former occupation _____

Social history _____

Family History (questions of special interest)

Number of siblings: _____ Sisters: _____ Brothers: _____

Number of children: _____ Daughters: _____ Sons: _____

Cardiovascular diseases: ☐ no ☐ yes: ☐ mother ☐ father ☐ brother ☐ sister ☐ others:
if yes, please specify: _____

Malignancies: ☐ no ☐ yes: ☐ mother ☐ father ☐ brother ☐ sister ☐ others:
if yes, please specify: _____

Metabolic disorders: ☐ no ☐ yes: ☐ mother ☐ father ☐ brother ☐ sister ☐ others:
if yes, please specify: _____

Haematological disorders: ☐ no ☐ yes: ☐ mother ☐ father ☐ brother ☐ sister ☐ others:
if yes, please specify: _____

Others: ☐ no ☐ yes: ☐ mother ☐ father ☐ brother ☐ sister ☐ others:
if yes, please specify:

Medication

Past medication: _____

_____

Current medication: _____

_____

Post exposure

Chief complaints and timing of symptoms on admission

Date/time	Complaint	Description

Vital signs on admission

Date/time	Sign	Description
	Blood pressure	
	Heart rate	
	Respiratory rate	
	Temperature	
	Others	

Radiation related health impairments of other organ systems

	Description	Consultation
Lung		☐ no ☐ yes
Heart		☐ no ☐ yes
Eyes		☐ no ☐ yes
Liver		☐ no ☐ yes
Bone and skeleton		☐ no ☐ yes
Endocrine system		☐ no ☐ yes
Lymph nodes		☐ no ☐ yes
Mucous membranes		☐ no ☐ yes
Salivary glands		☐ no ☐ yes
Others		☐ no ☐ yes

Use the following template to document ARS symptoms as a function of time according to the "Checklist" of ARS specific clinical symptoms of the four early reacting organ systems. Copy as required!

Patient ID:	Beginning of exposure:	Examiner:

Date and time of examination								
N	Degree of severity	Degree of severity	Degree of severity	Degree of severity	Degree of severity	Degree of severity	Degree of severity	Degree of severity
Nausea								
Vomiting								
Anorexia								
Fatigue syndrome								
Fever								
Headache								
Hypotension								
Neurological deficits								
Cognitive deficits								
Maximum								
Grading N								
H	Degree of severity	Degree of severity	Degree of severity	Degree of severity	Degree of severity	Degree of severity	Degree of severity	Degree of severity
Lymphocyte changes								
Granulocyte changes								
Thrombocyte changes								
Infection								
Blood loss								
Maximum								
Grading H								
C	Degree of severity	Degree of severity	Degree of severity	Degree of severity	Degree of severity	Degree of severity	Degree of severity	Degree of severity
Erythema								
Sensation/itching								
Swelling/oedema								
Blistering								
Desquamation								
Ulcer/necrosis								
Hair loss								
Onycholysis								
Maximum								
Grading C								
G	Degree of severity	Degree of severity	Degree of severity	Degree of severity	Degree of severity	Degree of severity	Degree of severity	Degree of severity
Frequency (stool)								
Consistency (stool)								
Mucosal loss/d (stool)								
Bleeding/d (stool)								
Abdominal cramps/pain								
Maximum								
Grading G								
Grading code	N_H_C_G_	N_H_C_G_	N_H_C_G_	N_H_C_G_	N_H_C_G_	N_H_C_G_	N_H_C_G_	N_H_C_G_
RC =								
Days after exposure								

The following template gives an overview of the laboratory tests to be performed repeatedly and documented as a function of time in order to capture the dynamics of the ARS. Copy as required!

Patient ID:	**Beginning of exposure:**	**Examiner:**

Date and time of examination														
	Unit	Normal values												
ARS symptoms														
Granulocytes														
Lymphocytes														
Platelets														
Fever														
Blood pressure														
Additional haematological parameters														
RBC														
Reticulocytes														
Haemoglobin														
Haematocrit														
MCV														
MCH														
ESR														

The following composite procedures and tests are not necessary to assess the ARS in the first instance but nevertheless provide important information as to the patient's course. This checklist documents for each day after exposure the type and quantity of examinations ordered. Thus it allows one to keep up with what has been ordered and what remains to be done. Finally, this list helps with writing up the clinical course of the patient as well as communication with colleagues. It should be used as a kind of "Table of contents" for subsequently attached stickers and forms of the corresponding results. Extend and copy as required!

Patient ID:	**Beginning of exposure:**	**Examiner:**

Days after exposure	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Date/time							
Blood clotting test							
Bile function							
Liver function							
Renal function							
Reproductive function							
Bone marrow cytogenetics							
HLA typing							
Arterial blood gases							
Differential blood							
Quantitative IgG, IgM, IgA levels							
Electrolytes							
Serum protein							
Blood glucose							
Inflammation parameters							
CSF examination							
Microbiological stool							
Occult blood in stool							
ECG							
EEG							
Chest radiograph (CXR)							
Abdominal radiographs							
MRI							
Search for stem cell donor							
Consultations							

PERSONAL NOTES