The Swiss Donation Pathway

Paediatric donor treatment

Recommendations for the topic

Treatment and monitoring of paediatric organ donors in neonatology and on paediatric intensive care units

Module — 4

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CNDO
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The term "organ donation" also includes tissue donation wherever appropriate.

1.0

Summary

1.1 Objectives

These guidelines and recommendations for donor treatment in the case of paediatric donors after brain death (DBD) are intended for use by medical and nursing professionals in accident and emergency departments and intensive care units in Switzerland. The aim is to minimise the number of donors lost due to inadequate donor treatment and thus increase the quantity and quality of organs available.

Maintaining the vital functions of the donor organ
According to the guideline of the Swiss Academy of Medical Sciences (SAMS)[1], preparatory medical measures must be carried out before and after the death of the patient. However, the decision to withdraw life-sustaining treatment must not be influenced by the possibility of organ donation.
Among the preparatory medical measures carried out before death are the continuation of existing treatments (continuation of ventilation, administration of medications and solutions to maintain circulatory function), laboratory analyses to guide treatment, and hormone replacement to maintain the internal milieu. Existing treatments may be continued, without counting as a preparatory medical measure, as long as they serve purposes other than organ removal (e.g. palliative care, enabling relatives to say goodbye).

1.2 Start of donor treatment

Monitoring and actual treatment as a potential donor begins after determination of brain death, in accordance with the SAMS guidelines on the diagnosis of brain death with regard to organ donation.

Preparatory medical measures for organ donation can be carried out after brain death if the patient has consented to organ donation (donor card). If the patient's wishes are not known, these measures can begin if the relatives or a legally designated representative have consented. However, these measures can only be carried out if all potential life-saving treatments have been exhausted and if there is no hope for recovery or death is inevitable.

One of the medical team's primary responsibilities is to ensure that a death in dignity is possible and to support the relatives during this difficult time.[2]

[1] SAMS, 2017, p. 7 / 17.
[2] SAMS, 2017, p. 8.

1.3 Life-saving emergency measures during donor treatment

In the case of cardiac arrest in a brain-dead patient during donor treatment, resuscitation, defibrillation and cardiac massage are strongly recommended.

Comment: This topic is not covered in the guidelines of the Swiss Academy of Medical Sciences.

1.4 End of donor treatment

As far as the intensive care team is concerned, monitoring and treatment of the organ donor ends as soon as the anaesthesiology team takes over and brings the patient to the operating theatre.

2.0

Point-by-point recommendations for donor treatment

2.1 Monitoring

Adequate organ perfusion and oxygenation are the most important therapeutic objectives after brain death has been diagnosed. These objectives can only be achieved by maintaining the cardiovascular, respiratory and metabolic systems.

Because the donor has lost neurological functions, vital functions, organ perfusion, and gas exchange must be monitored in a standardised manner.

Vital signs
- Continuous monitoring and recording of the electrocardiogram (ECG)
- Pulse oximetry
- Central and peripheral temperature measurement

Ventilation
- Documentation of ventilation parameters (tidal volume and ventilation pressures) every 12 hours, more frequently in the case of changes
- Transcutaneous or end-tidal CO_2 monitoring
- Chest X-ray, if required

Haemodynamics
- Continuous invasive blood pressure measurement
- Monitoring of cardiac output if appropriate (e.g. using PiCCO©)
- Continuous central venous pressure (CVP) monitoring (including curve)
- Continuous ECG monitoring, 12-lead ECG daily

- Monitor urine excretion via urine catheter on an hourly basis
- Measure capillary refill time every 2 hours
- Carry out a cardiac echocardiography initially, then repeat if low cardiac output syndrome is suspected, if spontaneous urine production is reduced or if the volume status cannot be clearly assessed (point-of-care ultrasound or possibly performed by a cardiologist)
- Central venous saturation every 4 hours together with arterial blood gas analysis, draw blood as close to the right atrium as possible
- Perform arterial blood gas analysis including lactate every 4 hours

2.2 Standard laboratory tests (for donor treatment only)

- Blood group (ABO and rhesus typing)
- Arterial blood gas analysis every 4 hours if values are in the normal range
- Electrolytes (Na, K, Cl, Ca) every 4 hours if stable, otherwise every 2 – 4 hours (e.g. due to diabetes insipidus)
- Creatinine, urea 1× per day
- Mg, phosphate, LDH, gamma-GT, ALP, CK, CK-MB, amylase, lipase, total protein, albumin, ASAT, ALAT, direct and indirect bilirubin, ammonia, CRP once if normal
- Blood glucose every 4 hours if stable, every 2 – 4 hours in the case of hyperglycaemia or hypoglycaemia
- Lactate every 4 hours if stable, every 2 – 4 hours if elevated
- Troponin daily
- Serum osmolality daily, or every 12 hours in the case of diabetes insipidus
- Haemoglobin and leukocytes daily if stable, or every 6 – 12 hours in the case of active bleeding
- Coagulation: international normalized ratio (INR), PTT, prothrombin time daily if stable
- Urine analysis (spot and sediment) once, if normal
- Microbiology: in the case of a suspected infection, take the appropriate cultures, e.g. from the blood, urine and tracheal secretions; in the case of a suspected viral infection, also perform a nasopharyngeal swab

2.3 Specific laboratory tests for organ procurement

HLA typing and virology tests should be performed before any blood products are administered:

- HLA typing (in the reference hospital)
- Serology: HIV, Hepatitis B and C, CMV, toxoplasmosis, EBV, HTLV-1 and -2, herpes simplex and zoster, TPHA

2.4 Haemodynamics

Maintaining adequate blood pressure is crucial for organ perfusion. The following minimum values are recommended for children.

	Mean arterial pressure (MAP) (mmHg)	Systolic blood pressure (mmHg)
Neonates	40	50 – 60
4 – 8 kg	45 – 50	60 – 70
10 – 20 kg	50 – 60 – 65	70 – 80
Adolescents	60 – 80	90 – 100

Signs of adequate organ perfusion
- Warm extremities and good capillary refill time
- Lactate values within the normal range
- Normal urine excretion (1 – 3 ml / kg / hrs)
- Central venous saturation >70%
- Pulse within the normal range (in the case of normothermia)

Age	1 – 5 months	6 – 12 months	1 – 5 years	>5 years
Pulse in bpm	45 – 50	60 – 70	80 – 100	70 – 90

Careful, regular checks on intravascular volume status are very important in terms of ensuring optimal organ perfusion with minimal use of vasopressors.

Interventions

Hypovolaemia
- Crystalloids (NaCl 0.9%, Ringer's lactate, Ringer's acetate) except for:
  - Hb <70 g / l: erythrocytes concentrate
  - Fibrinogen <1 g / l: FFP, except in the case of hyperfibrinolysis
  - Thrombocytes <10 g / l: thrombocytes concentrate

Hypervolaemia
- Diuretics (e.g. furosemide)

If organ perfusion objectives are not met:
- Rule out obstructive forms of shock (tension pneumothorax, pulmonary embolism and pericardial effusion)
- Check cardiac function by
  - Checking clinical symptoms
  - Echocardiography – consider cardiac support depending on the findings
  - Checking central or mixed venous saturation (elevated O_2 extraction rate)
  - Possibly measuring cardiac output and / or systemic vascular resistance

Management of poor organ perfusion due to cardiac insufficiency

Cardiac insufficiency, normal blood pressure
Milrinone (0.5 – 1 mcg / kg / min.) and / or dobutamine (2.5 – 5 mcg / kg / min.)

Cardiac insufficiency and signs of systemic vasoconstriction
Milrinone (0.5 – 1 mcg / kg / min.) and sodium nitroprusside (0.1 – 1 mcg / kg / min.)

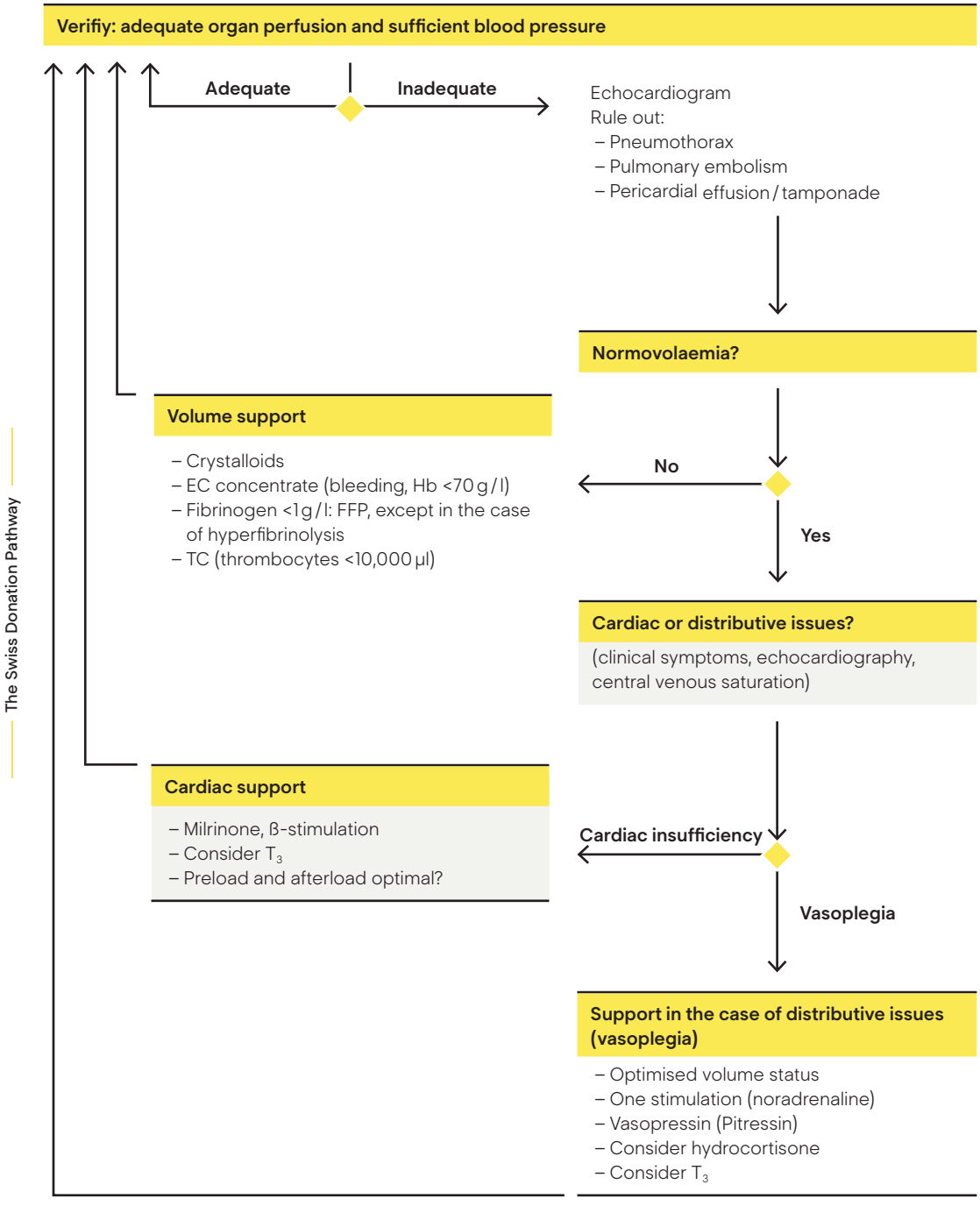
Cardiac insufficiency with systemic hypotension
Adrenaline (0.05 – 1 mcg / kg / min.), or milrinone (0.5 – 1 mcg / kg / min.) and noradrenaline (0.1 – 0.5 mcg / kg / min.) or instead of noradrenaline vasopressin 0.0003 – 0.002 U / kg / min. (Note: Increasing the cardiac output at a heart rate of >160 – 170 bpm also increases the oxygen requirements of the myocardium. Check that all cardio-depressive medication has been stopped and that the patient is normothermic.)

If the above measures are unsuccessful, consider T_3 substitution (0.05 mcg / kg / hrs)

If cardiac decompensation persists, consider low-dose hydrocortisone

Hypotension caused by distributive decompensation, indicated by:
- Elevated heart rate, warm extremities
- Preserved ventricular function by echocardiography
- Central or mixed venous saturation normal or elevated

Vasopressor therapy	Support measures
Optimise volume status	Consider hydrocortisone (3 × 2 – 5 mg / kg / day)
Noradrenaline (0.1 mcg / kg / min., up to 0.5 mcg / kg / min. could be required)	Consider T_3 as mentioned above
Arginine vasopressin 0.0003 – 0.002 U / kg / min.	First line treatment in case of diabetes insipidus



Algorithm for treatment of insufficient organ perfusion

Treatment of arterial hypertension

Arterial hypertension with normocardia
- Sodium nitroprusside (0.1 – 1 mcg / kg / min.)
- Alternative:
  - Phentolamine (0.2 – 1 mcg / kg / min.)
  - Clonidine (0.5 – 2 mcg / kg / hrs)

Arterial hypertension with tachycardia:
- Clonidine (0.5 – 2 mcg / kg / hrs)
  fewer cardio-depressive side effects than
- Esmolol (25 – 150 mcg / kg / min.)

Arrhythmias

Bradycardia
- In the case of bradycardic sinus rhythm: Check body temperature, electrolytes and administered medications (esmolol or clonidine)
- Consider dobutamine 5 mcg / kg / min. or orciprenaline (0.1 mcg / kg / min.) as a continuous infusion
- In the case of a complete AV block (grade 3), external pacing or temporary transvenous pacer with simultaneous administration of orciprenaline as a bridging measure

Tachyarrhythmia
- Check body temperature (35 °C – 37.5 °C), oxygenation and electrolytes
- Consider cardioversion
- Start with amiodarone bolus (5 mg / kg bolus over 1 hour) and then 15 – 20 mg / kg / d (10 – 15 mcg / kg / min.) as a continuous infusion

2.5 Mechanical ventilation

- Oral or nasal intubation, endotracheal tube with cuff
- Tracheal suction with open or closed suction system, depending on the indication (secretion or deoxygenation). Caution: minimise suction to prevent tracheal injury
- Use of lung protective ventilation:
  - Positive end-expiratory pressure (PEEP), minimum 5 cmH_2O, in the case of restrictive lung disease (Paediatric Acute Respiratory Distress Syndrome – PARDS), higher in accordance with the "low PEEP / high FiO_2" ARDS Network Strategy, and a validation study on this conducted in children
  - Small tidal volume (VT 6 ml / kg, higher if no lung disease)
- Plateau pressure should remain below 28 cmH_2O. If higher pressures are required, high-frequency ventilation should be considered
- High-frequency ventilation can be used as follows:
  - Neonates: 15 Hz, infants and young children: 12 Hz, children and adolescents: 12 – 9 Hz, in the case of insufficient CO_2 exhalation, first increase the amplitude, and if this is not sufficient, reduce the frequency

- MAP (Mean airway pressure): start with 2 – 5 cmH_2O higher than the MAP with conventional ventilation
- Pressure amplitude: high enough to ensure shaking of the chest
  Adjustments according to arterial blood gas analysis (ABGA)
- Permissive hypercapnia (maintain pH >7.25) and hypoxaemia (SaO_2 >85%) can be used to prevent potential machine-associated lung injury and oxygen toxicity.

In patients with high oxygen requirements or deoxygenation: Perform recruitment manoeuvres (increase MAP, increase PEEP) until oxygenation improves. (Maximum value can vary from patient to patient.) Afterwards, reduce MAP or PEEP step by step until 2 cmH_2O over occlusion pressure.

2.6 Haemoglobin

Objective
- Haemoglobin >70 g/l in stable patients (no increased requirement for inotropic support and no volume requirement in the last 2 hours)
- Aim for higher Hb/HCT values in haemodynamically unstable or cyanotic patients or in patients with haemoglobinopathies (target 100 g/l, controversial)

Interventions
- Transfuse erythrocytes concentrate through a 170 – 260 µm filter
  (3 ml/kg increases Hb by about 5 – 10 g/l)
- Use leukocyte-depleted concentrates; CMV-negative donor for CMV-negative recipient if possible
- Fill all specimen tubes for HLA and serology prior to any transfusion!

2.7 Thrombocytes

Objective
- Thrombocytes >10 g/l, if no bleeding
- Thrombocytes >50 g/l in the case of bleeding
- Thrombocytes of >100 g/l in the presence of life-threatening bleeding, in the case of intracranial bleeding and prior to major invasive procedures

Interventions
- Transfusion: 1 – 2 bags of thrombocytes per 10 kg body weight (max. 6 bags) via a 80 – 170 µm filter. (pooled; for multi-transfused recipients with antibodies of matching individual donors)
- Fill all specimen tubes for HLA and serology prior to any transfusion!

2.8 Coagulation

Objective
INR: <2.0 in the case of bleeding or prior to major invasive procedures

Interventions
- Check INR regularly in the absence of bleeding, without transfusion (no studies have conclusively demonstrated an association between elevated INR and spontaneous bleeding)
- In the case of elevated INR, administer vitamin K 0.3 mg / kg i.v. (max. 10 mg every 6 – 24 hours)
- Transfusion of FFP 10 – 15 ml / kg until bleeding stops (not to normalize INR), ideally AB0 compatible; neither crossmatch nor rhesus compatibility is required
- If volume administration with fresh frozen plasma (FFP) is contraindicated or if bleeding does not stop despite FFP
  ⟶ Consult the responsible haematologist about whether factors are required (Prothromplex® or Beriplex®, dose 25 U / kg = 1 ml / kg of factor VII)

Objective
Fibrinogen: >1 g / l

Interventions
- Fibrinogen administration (Haemocomplettan®) 20 – 40 mg / kg i.v.
- Protamine hydrochloride (1 mg / 100 U heparin or 0.5 / 100 U heparin, if last dose >1 hour) in patients treated with heparin
- Active inhibition of fibrinolysis, e.g. tranexamic acid (Cyklokapron®, 10 – 15 mg / kg over the course of 8 hours i.v.)

2.9 Diabetes insipidus

Diagnosis (Cheetham 2002 and Ghirardello 2007)
- Urine excretion >2 l / m^2 / day or 4 ml / kg / hrs for 2 consecutive hours
- Serum sodium 145 mmol / l and increasing (caution: may increase rapidly!)
- Serum osmolarity ≥300 mOsm / l
- Urine osmolarity ≤300 mOsm / l
- Or urine / serum osmolarity ratio <1

Objective
- Normovolaemia
- Normal serum sodium
- Normal serum osmolarity

Interventions
- Acute management in the case of hypotension: Continuous infusion with arginine vasopressin (Pitressin®, t1 / 2 5 – 10 min.) 1 – 2 mU / kg / hrs or 2 – 5 U in 1l NaCl 0.9% and replace urine output +10% every hour
- Stable patient: Desmopressin (Minirin®, t1 / 2 8 – 12 hours) nasal 5 – 10 µg 12 – 24 hours (not per kilogram!) or 0.5 – 2 µg in 1 l NaCl 0.9% and replace urine output +10% every hour

2.10 Sodium

Objective
Serum sodium: 135 – 145 mmol / l

Interventions
– Monitoring of weight, urine excretion, serum and urine sodium and osmolarity

Hypernatremia
– In the case of chronic asymptomatic hypernatraemia, aim for a lowering of serum sodium of maximum 0.5 mmol / l / hrs until the target range is reached
  In the case of acute symptomatic hypernatraemia, aim for a lowering of serum sodium of maximum 1.5 – 2 mmol / l / hrs

  Reduce sodium supply: infusions, additives (e.g. bicarbonate, phosphate), medicines and i.v. medication
– Check diuresis for osmotic diuresis (e.g. hyperglycaemia, mannitol)
– In the case of hypovolaemia: Administer a volume bolus (initially NaCl 0.9%, then change to hypotonic or balanced solutions to achieve a reduction in sodium)
– In the case of diabetes insipidus: vasopressin and desmopressin as described above

Hyponatraemia (supplementation according to Na deficit)
– In the case of chronic hyponatremia, aim for an increase in Na+ of 0.5 mmol / l / hrs in the case of acute symptomatic hyponatremia 1.5 – 2 mmol / l / hrs
– Acute symptomatic hyponatraemia: NaCl 3% 1 – 3 ml / kg in order to increase serum sodium to >125 mmol / l
– Hypovolaemia: for maintenance and rehydration ->infusion of NaCl 0.9% over the course of 48 hours and replace further fluid losses
– For hypervolaemia or signs of hypersecretion of ADH (hyponatraemia, normovolaemia, urine sodium >20 mmol / l, urine / serum osmolarity >1): Restrict intake, consider diuretics

2.11 Other electrolytes

Objective
Keep electrolytes (Ca, K, Mg and PO_4) in the normal range

Interventions
– Substitute electrolytes if necessary. In the case of increased Ca, K or PO_4 requirements, consider the possibility of hypomagnesaemia (even with normal serum magnesium levels) and replace if necessary
– Administer i.v. magnesium and calcium **slowly** to prevent arterial hypotension and / or bradycardia
– In the case of massive transfusion (especially FFP): substitute Ca

2.12 Body temperature

Objective
35 °C – 37.5 °C core body temperature

Interventions

Hypothermia:
– Cover with warm covers and consider warm infusions

Hyperthermia:
– Cover with cooling covers and use ice packs; cool the patient and rule out an infection

2.13 Blood glucose

Objective
Target 4 – 10 mmol / l

Interventions

Hyperglycaemia
– Reduce glucose supply as far as possible and possibly cautiously use a continuous infusion of insulin

Hypoglycaemia
– Increase glucose supply, consider using higher concentrations (e.g. 30% glucose), depending on volume status and electrolyte status

2.14 Corticosteroids

In the case of cardiovascular instability, if the patient requires inotropic and vasoactive substances:
– Low-dose corticosteroids (consider intravenous hydrocortisone 1 – 5 mg / kg every 6 – 8 hrs)
– No ACTH test required prior to administration

Discuss high-dose corticosteroids (intravenous methylprednisolone 15 mg / kg) with the transplant team in the case of planned lung procurement.

2.15 Antibiotic therapy

No prophylactic treatment. Treat any confirmed or suspected infection in accordance with standard practice in the department.

2.16 Feeding

- Enteral or parenteral feeding and the replacement of vitamins and trace elements should be continued.
- Consider glucose reduction in the case of hyperglycaemia.

2.17 Recommendations for care management of organ donors in paediatric intensive care

The nursing staff are responsible for clinical monitoring and the implementation of the prescriptions that doctors have set based on the recommendations for donor treatment. The nursing staff inform the doctor about any changes in vital parameters that could affect the preservation of the organs.

Paediatric donor care is a process that can take several hours. Continued optimal management is therefore crucial.

In addition to the supervision and care that the brain-dead child must receive, it is important to grant the parents and the family unrestricted freedom to visit the child, even during additional examinations.

Comfort care (massage, positioning etc.), hygiene measures (preoperative cleansing, oral hygiene etc.) and prevention of infectious complications (tracheal aspiration, urinary catheter care etc.) must be carried out in accordance with the protocols of the hospital in question. The frequency of these measures should be adapted according to the situation and needs of the child and their family.
It is essential to explain why these care measures are taken in order to avoid causing any confusion or false hope.

The parents should also be allowed to take part in the hygiene and comfort care measures if they wish.

The option to accompany the child to the operating theatre and to see the child again after the operation should be discussed with the family and planned for as appropriate.

These recommendations apply in accordance with the standards and reference documents of the institution and service where the child is being cared for.

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Changes

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March 2018	3.1	New logo
April 2014	3.0	Layout and title adapted
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