After an initial good recovery there can still be a rapid clinical deterioration after 4–6 hours with respiratory compromise and the need for endotracheal intubation and mechanical ventilation. Chest X-ray changes may occur later.

Whatever the method of rescue, patients should be lifted out of the water in a horisontal position and if possible with their spine immobilised. Vertical rescue may lead to cardiovascular collapse due to loss of pressure from surrounding water and venous pooling.

Hypothermia

A core temperature reading (rectal or oesophageal) should be obtained as soon as possible and further cooling should be prevented immediately. Hypothermia is common following drowning, and adversely affects resuscitation attempts unless treated. Not only are arrhythmias more common but some, such as ventricular fibrillation, may be refractory at temperatures below 30◦C. Defibrillation, according to CPR guidelines, may be attempted at temperatures below 30◦C; if unsuccessful, further shocks must be delayed until there has been a rise in temperature to above 30◦C. Administration of inotropic or antiarrhythmic drugs should not be given when the core temperature is below 30◦C. Resuscitation should be continued until the core temperature is at least 32◦C or cannot be raised despite active measures.

Rewarming strategies depend on the core temperature and signs of circulation. External rewarming is usually sufficient if the core temperature is above 30◦C. Active core rewarming should be added in patients with a core temperature of less than 30◦C, but beware of "rewarming shock". Most hypothermic patients are hypovolaemic. During rewarming the peripheral vascular resistance falls more rapidly as core rewarming is accomplished. As a result of vasodilation and impaired myocardial dysfunction, hypotension ensues.

External rewarming

- Remove cold, wet clothing
- Supply warm blankets
- Infrared radiant lamp
- Heating blanket
- Warm air system

Core rewarming

- Warm intravenous fluids to 39◦C to prevent further heat loss
- Warm ventilator gases to 42◦C to prevent further heat loss
- Gastric or bladder lavage with normal (physiological) saline at 42◦C
- Peritoneal lavage with potassium-free dialysate at 42◦C. Use 20 ml/kg cycled every 15 minutes
- Pleural or pericardial lavage
- Endovascular warming
- Extracorporeal blood rewarming

The temperature is generally allowed to rise by 1◦C per hour to reduce haemodynamic instability. However, recent evidence suggests that in post-cardiac-arrest patients with restoration of adequate spontaneous circulation there has been a beneficial effect on neurological outcome of mild hypothermia (32–34◦C) for 12–24 hours when the initial rhythm was ventricular fibrillation. The data on the use of therapeutic hypothermia in children are so far insufficient.

External and internal rewarming methods are shown in the box. Rhythm, pulse rate and blood pressure monitoring should be undertaken. In severe hypothermia, admission to a high-dependency area is necessary.

19.11 SECONDARY SURVEY AND LOOKING FOR KEY FEATURES

During the secondary survey, the child should be carefully examined from head to toe. Any injury may have occurred during the incident that preceded immersion; spinal injuries are particularly common. Ingestion of alcohol and/or drugs may have preceded the drowning incident in the older child.

Investigations

- Blood glucose
- Blood gas analysis (preferably arterial) and blood lactate
- Urea and electrolytes
- Coagulation status
- Blood and sputum cultures
- Chest X-ray
- Lateral cervical spine X-ray or CT scan.

19.12 EMERGENCY TREATMENT AND STABILISATION

The brain is the most vulnerable organ for asphyxia, and cerebral impairment occurs before cardiac problems in submersion. Except for bystander cardiopulmonary resuscitation and mild hypothermia in specific patients, there are few effective measures for reducing brain damage in drowning.

It is essential to monitor the vital functions closely, especially during the first couple of hours. An early suggestion of respiratory insufficiency or haemodynamic instability is an indication for admission to the intensive care unit.

Fever is common during the first 24 hours following immersion and this is not necessarily a sign of infection. In fact infections usually become manifest after the first day when gram-negative organisms, especially *Pseudomonas aeruginosa*, are common. Aspergillus species has also been reported in drowning victims. Broad-spectrum intravenous antibiotic therapy (such as cefotaxime) should be started after blood and sputum cultures have been repeated.

Signs of raised intracranial pressure (ICP) may develop, probably as a result of a posthypoxic injury. Aggressive treatment of a raised ICP has not however been shown to improve the prognosis. Other therapeutic measures, such as barbiturates, calcium channel blockers and free-radical scavengers have not shown any beneficial effects in clinical practice. But keeping the patient normoglycaemic is of importance for the optimal recovery of the injured brain.

19.13 PROGNOSTIC INDICATORS

The clinical course of drownings is determined by the duration of hypoxic–ischaemic injury and the adequacy of initial resuscitation. It is assumed that hypoxic brain damage is reduced when the brain cools before the heart stops. There is no single factor that can reliably predict good or poor outcome in drowning. Still, the following factors may give an indication on outcome.