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Neurocognitive long term follow-up study on drowned children

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ABSTRACT

Aim of the study: Report cognitive and neurological outcome later in life of surviving drowned children who had received CPR either from bystanders or from emergency medical services (EMS) units.
Methods: Forty children who had drowned and admitted to pediatric intensive care unit after successful CPR between 1985 and 2007, were eligible for the study. Of those 21 gave a consent for neurological and neuropsychological examinations. All data are expressed as median (interquartile range). Mann-Whitley *U*, Wilcoxon signed ranks and Chi square tests were used.
Results: The median age of the 21 patients at drowning was 2.4 (1.8, 5.5) years and 12.5 (8.6, 19.4) years at the time of neurological and neuropsychological examination. The median interval between the drowning accident and examinations was 8.1 (5.4, 14.4) years. Twelve patients (57.1%) had either signs of minor (6/21) or major neurological dysfunction (6/21). Eight subjects (40.0%) had full-scale intelligence quotient (FIQ) of less than 80 (range 20–78). The median estimated submersion time of the subjects with normal FIQ was 3.5 (2.0, 7.5) min, which was significantly shorter than for those with FIQ < 80, 12.5 (5.0, 22.5) min ($p = 0.0013$). Cognitive or neurologic deficits were detected in 17 of the 21 subjects, although 11 of them were reported to have a full recovery at the hospital discharge.
Conclusions: This study showed that 57% of the drowned and resuscitated children had neurological dysfunction and 40% a low FIQ. Neurological and neuropsychological long term follow-up in drowned children is highly recommended.

1. Introduction

Accurate prognosis of a surviving drowned child cannot be predicted from the initial presentation or examinations on arrival to hospital. Only limited data on the long term neurocognitive outcome after a drowning incident are available. The variability in the definitions of the patient population and the outcome measurements used in previous studies make it difficult to assess long term outcome.[1–8] The patient populations of earlier studies varied from children who had been subjected to drowning for a short time without cardiac arrest to hypothermic children who were brought to the hospital with ongoing cardiopulmonary resuscitation (CPR) and rewarmed by cardiopulmonary bypass.[1–8] Consequently, the survival rates of these study populations varied between 11% and 100%.[5,6] A study by Pearn showed that 95% of the children who were admitted to hospital after a drowning accident, were completely neurologically normal and had a median intelligence quotient (IQ) higher than that of the general population.[5] However, other studies on drowning children for whom CPR was initiated by emergency medical services (EMS) unit at the accident site, reported survival rates with mild or no neurological deficits of only 14–21%.[1,2]

The quality and timing of outcome evaluation will affect the results. Complete neurological and neurocognitive examinations of drowning victims are superior to using outcome scales based on chart reviews. The former are used to assess higher cortical functions such as memory or executive functions.[9,10] Young drowning survivors may function at a level consistent with age-expectations at discharge, but long-term cognitive sequelae may not manifest until the child enters school or some defects such as executive functions do not become fully apparent until early adolescence.[8,11]

This is the first long term follow-up study of a comprehensive patient–survivor population of children who underwent drowning

Abbreviations: CPR, cardiopulmonary resuscitation; EMS, emergency medical systems; IQ, intelligence quotient; PICU, pediatric intensive care unit.

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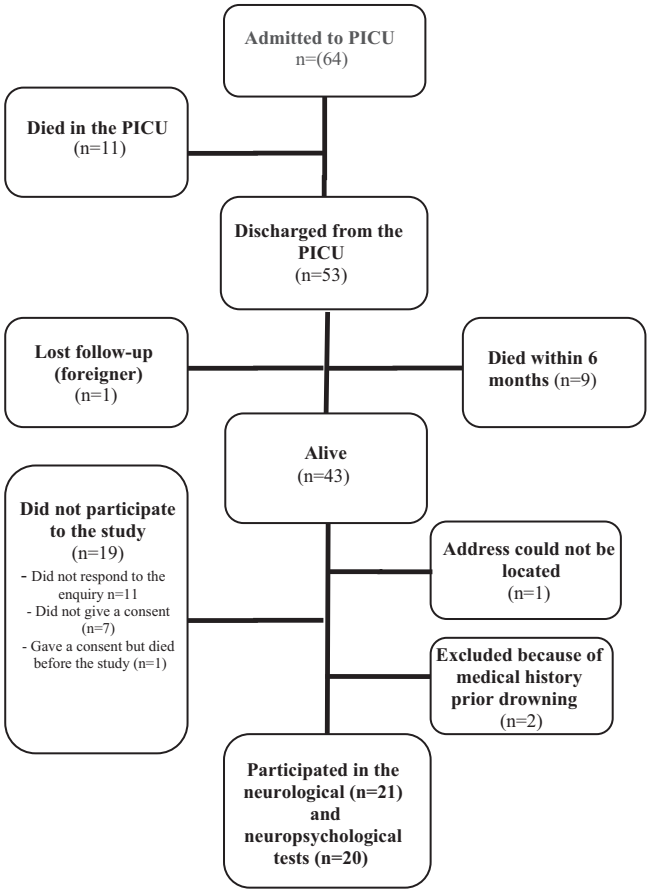

Fig. 1. A scheme for drowned children admitted to PICU.

as a child for whom CPR was attempted either by bystanders or by EMS personnel. It aims at determining the neurocognitive outcome after drowning and whether factors such as the length of submersion time are associated with cognitive function and neurological presentation later in life.

2. Materials and methods

Approval of ethics committee of Helsinki University Central Hospital was obtained for the prospective long term follow-up study of the drowned children. The medical records of all drowned children who were successfully resuscitated either by a layperson or by EMS personnel and admitted to the Pediatric Intensive Care Unit (PICU) at the Children's Hospital of Helsinki University Central Hospital between the years 1987 and 2007 inclusive, were analyzed retrospectively. All drowned children were taken to the paediatric intensive care unit (PICU) at the Children's Hospital as per EMS protocol. Information sources included pre-hospital EMS and medical records. The temperatures of lakes, rivers and sea surface waters were obtained from the Finnish Institute of Environment Agency and the Finnish Institute of Marine Research. Baltic seawater contains little sodium chloride (0.02–0.75%), therefore all incidents in this study can be considered as freshwater submersions.

Sixty-four patients were admitted to the PICU (Fig. 1). The Finnish Population Register provided the current addresses of the survivors, who were discharged alive and information about whether the child had died later. Two patients had pre-existing medical conditions that seriously impacted upon their physical and cognitive condition prior to the submersion incident; one with moderate neurological defects due to meningitis a few years prior to the drowning incident and the other with autistim caused by the Kabuki syndrome. A letter was sent to the 40 survivors, who were alive and whose address were available. One reminder letter was sent for the non-responders. The letter included a questionnaire that covered the health-related quality of life (HRQoL) and education level the subjects had attained and also a consent form for neurological and neuropsychological examinations had to be signed. Twenty-nine subjects returned the complete HRQoL questionnaire and these results were reported earlier.[7] Seven subjects declined to participate in the clinical study and one subject died before the clinical study due to a cause that was unrelated to the childhood submersion incident. The seven subjects who did not give a consent, were all reported to have full recovery at the hospital discharge.

Table 1
The incidence of neurological dysfunction in children who survived drowning ($n = 21$).

Cluster of dysfunction and signs according to Hadders-Algra[12]	The number of patients (percent) with cluster abnormality
Dysfunctional muscle tone regulation (≥1 deviations) Muscle tone Posture during sitting, crawling, standing and walking	4 (19.0%)
Reflex abnormalities (≥2 signs) Abnormal intensity and/or threshold or asymmetry in: biceps reflex, knee and ankle jerk Foot-sole response: uni- or bilateral Babinski sign	2 (9.5%)
Choreiform dyskinesia (≥1 movements) Spontaneous motor behavior Movements of face, eyes, tongue	1 (4.8%)
Co-ordination problems (≥2 tests) Finger-nose test, fingertip touching test, diadochokinesis, Romberg, tandem gait, standing one foot	11 (52.4%)
Fine manipulative ability (≥2 tests) Finger opposition test: smoothness and transition Quality of hand and arm movements Pincher grasp Tremor	9 (42.9%)
Rarely occurring miscellaneous disorders (≥1 signs) Motor behavior of face, eyes, pharynx and tongue Associated movements during DDK, finger-opposition test, walking on toes or heels At least one of the following: Mild cranial nerve palsy and excessive associated movements	4 (19.0%)

Neurological ($n = 21$) and neuropsychological examinations ($n = 20$) were performed between November 2009 and December 2010, except for one patient with severe anoxic brain injury who needed full time care in a nursing home. She was unable to attend to the neurocognitive examinations and her condition was evaluated by tests done in our hospital in 2002, five years after the drowning. One of the 21 patients who participated in the neurological examination did not attend the neuropsychological examination despite several scheduled appointments and reminders.

All the neurological examinations were done by one pediatric neurologist (coauthor NS) and data were reported according to criteria for abnormal functional clusters of minor neurological dysfunction described by Hadders-Algra (Table 1).[12] Subjects with minor neurological dysfunction have one or two cluster abnormalities and subjects with major dysfunction have abnormalities in three or more clusters.