CANADIAN STROKE BEST PRACTICE RECOMMENDATIONS

Stroke Rehabilitation Evidence Tables
Paediatric Stroke Rehabilitation

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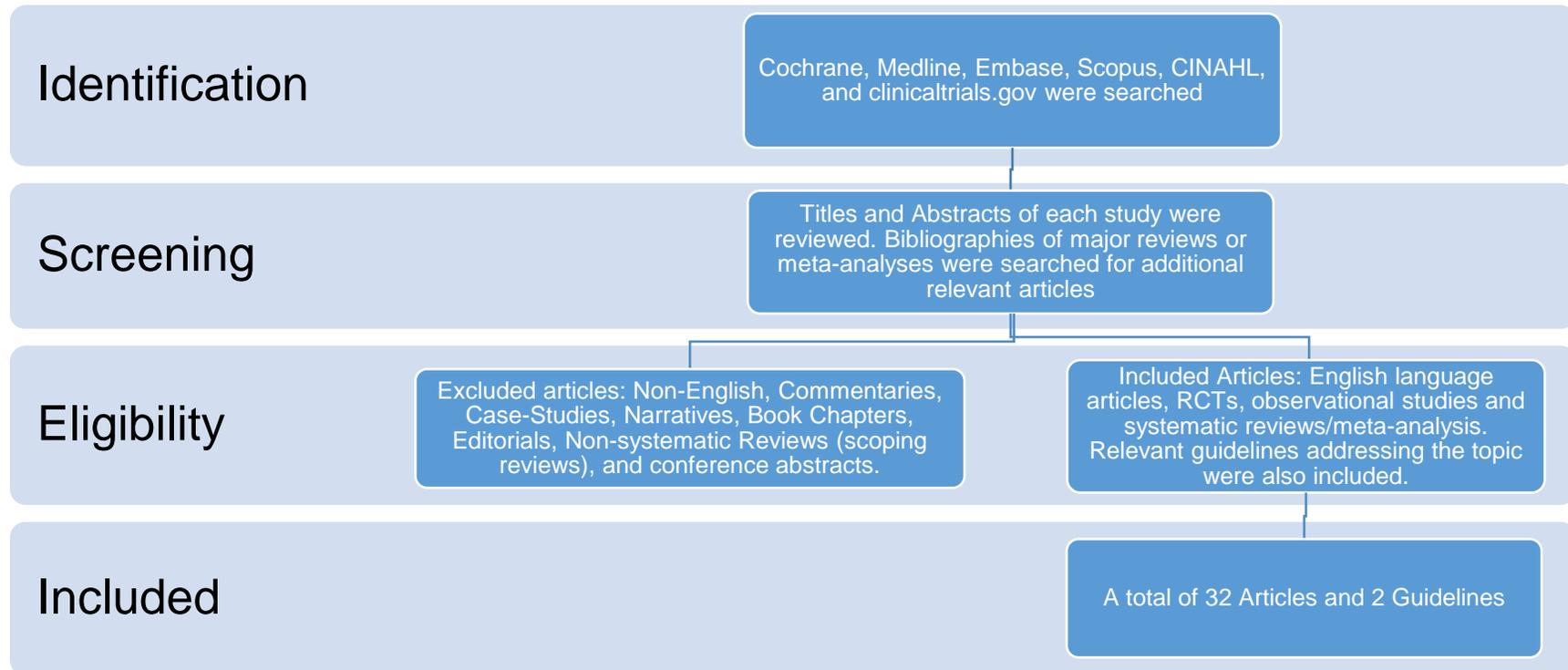
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Search Strategy

Identification	Cochrane, Medline, Embase, Scopus, CINAHL, and clinicaltrials.gov were searched

Screening	Titles and Abstracts of each study were reviewed. Bibliographies of major reviews or meta-analyses were searched for additional relevant articles

Eligibility	Excluded articles: Non-English, Commentaries, Case-Studies, Narratives, Book Chapters, Editorials, Non-systematic Reviews (scoping reviews), and conference abstracts.	Included Articles: English language articles, RCTs, observational studies and systematic reviews/meta-analysis. Relevant guidelines addressing the topic were also included.

Included	A total of 32 Articles and 2 Guidelines

Cochrane, Medline, Embase, Scopus, CINAHL, and clinicaltrials.gov were searched using the keywords: Stroke AND (pediatric OR paediatric OR child OR children OR young OR juvenile OR perinatal OR baby OR infant OR neonatal OR antenatal OR maternal OR parental) AND (rehabilitation OR therapy OR intervention). Titles and abstract of each article were reviewed for relevance. Bibliographies were reviewed to find additional relevant articles. Articles were excluded if they were: non-English, commentaries, case-studies, narrative, book chapters, editorials, non-systematic review, or conference abstracts. Additional searches for relevant best practice guidelines were completed and included in a separate section of the review. A total of 32 articles and 2 guidelines were included and separated into categories designed to answer specific questions.

Published Guidelines

Guideline	Recommendations
Stroke in childhood Clinical guidelines for diagnosis, management and rehabilitation. Prepared by the Paediatric Stroke Working Group. November 2004.	Activities of daily living (Evidence: Consensus of working party) 1. Therapists working with a child affected by stroke should assess the child's ability to perform daily living activities 2. An occupational therapist should be involved in identifying therapeutic need in self-care, work/school and leisure activities and provision of intervention in this area if indicated. Return to school 1. Child health services, usually community child health services, should take responsibility for informing the local education authority of children who may have special educational needs as soon as possible after the stroke (D) (Evidence: Special educational needs code of practice (DfES 2002). Department of Education and Skills 558/2001) 2. The child's key worker should liaise with the special educational needs coordinator at the child's school prior to school return (D) (Evidence: Special educational needs code of practice (DfES 2002). Department of Education and Skills 558/2001; Special educational needs toolkit (DfES 2001)) 3. A collaborative meeting should be undertaken to plan educational provision with appropriate assessment or support (D) (As above; Access to education for children and young people with medical needs (DfES 2001)) 4. Health and school staff should agree procedures for communicating information (Consensus of working party) 5. For children presenting with mobility difficulties, the school environment should be assessed prior to return to school, ideally by an occupational therapist (Consensus of working party) 6. It is recommended that all children affected by stroke are placed on a minimum of School Action (see above) as many difficulties remain latent (Consensus of working party)
Roach et al. Management of Stroke in Infants and Children: A Scientific Statement From a writing Group of the American Heart Association Stroke Council and the Council on Cardiovascular Disease in the Young. (Stroke. 2008;39:2644-2691.)	Recommendations for Rehabilitation After a Child's Stroke Class I Recommendations 1. Age-appropriate rehabilitation and therapy programs are indicated for children after a stroke (Class I, Level of Evidence C). 2. Psychological assessment to document cognitive and language deficits is useful for planning therapy and educational programs after a child's stroke (Class I, Level of Evidence C).

Evidence Tables

Rehabilitation Therapies

Study/Type	Quality Rating	Sample Description	Method	Outcomes	Key Findings and Recommendations
Repetitive Transcranial Magnetic Stimulation					
Kirton et al. 2008 **Canada** **RCT**	CA: ☒ Blinding: Patients ☒ Assessors ☑ ITT:☒	10 pediatric patients with arterial ischemic stroke (>2 years post-stroke) with hand motor impairment. Age 8.6 years to 20.7 years; 60% male. **Inclusion criteria:** <21, years of age, age at time of stroke >28 days. **Exclusion criteria:** presence of seizures, high risk of recurrent stroke.	Based on age and level of hand weakness, patients were matched. One patient was placed in the control group and the other placed in the intervention group. Intervention group received 20 min of 1 Hz frequency and 1200 stimuli on the non-lesioned side parallel to the motor cortex. Control group also received 20 min of 1Hz frequency and 1200 stimuli, but the coil was placed perpendicular to the skull. Treatment lasted for 8 days.	**Primary outcomes:** Melbourne assessment of upper extremity function (MAUEF) and grip strength (using dynamometer). **Secondary outcomes:** Purdue peg board test (PPT), Halstead-Reitan finger tapping (HRFT), in-hand manipulation (IHM) **Assessment time points:** Day 5, after 4th treatment, Day 10, after 8th treatment, Day 17, 1 week after treatment.	There was no statistically significant difference in MAUEF between groups (p=0.15). There was a significant interaction between time and the effect of treatment on grip strength (p=0·03). Statistical comparisons between groups for the secondary outcomes were not possible due to small sample size.
Gillick et al. 2014 **USA** **RCT**	CA: ☒ Blinding: Patients ☑ Assessors ☑ ITT:☒	19 pediatric patients with congenital hemiparesis from a stroke or periventricular leukomalacia (Mean age 10 years, 10 months; 47.3% male.). **Inclusion criteria:** <21 years of age, <10° of active finger movement, and the presence of a motor evoked potential from ipsilesional primary motor cortex. **Exclusion criteria:** metabolic disorders, neoplasm, seizure within the past 2 years, botulinum toxin or phenol block treatment within the past 6	Patients were randomized into five sessions of either active rTMS (n=10) or sham rTMS (n=9) alternated daily with constraint-induced movement therapy (CIMT). CIMT consisted of 13 days of continuous long-arm casting with five skin-check sessions. Each child received a total of 10 hours of one-to-one therapy.	**Primary outcomes:** Assisting Hand Assessment (AHA) **Secondary outcomes:** Canadian Occupational Performance Measure (COPM) and stereognosis.	There was a significant improvement in the rTMS group compared to the sham group in AHA scores (p=0.007). No significant differences in the secondary outcome measure were reported (p>0.05).

Study/Type	Quality Rating	Sample Description	Method	Outcomes	Key Findings and Recommendations
		months, disorders of cellular migration, hemorrhagic brain lesion, receptive aphasia, pregnancy, indwelling metal or gross visual field cuts, or current involvement in a formal rehabilitation program.			
Functional Electrical Stimulation					
Kapadia et al. 2014 Canada **Pre-Post Test**	N/A	4 severe chronic pediatric stroke patients (Age 6 years to 11 years, 50% male, Time since injury: 14-84 months). Inclusion criteria: (1) Hemiplegia due to single stroke at least 1 year prior to the date of recruitment to the study;(2) Severe hemiplegia with inability to use the affected arm and hand for functional activities;(3) May or may not have any motor function preserved in the arm; (4) The upper limb muscles of interest must respond to electrical stimulation;(5) Ability to understand and follow instructions in English. Exclusion criteria: (1) Fixed contractures of the hand and Wrist; (2) Serious cognitive or psychological impairments; (3) Presence of a skin rash at potential electrode site; (4) Cardiac pacemaker; (5) Shoulder hand syndrome; (6) Loss of proprioception as assessed using the Thumb Localization Test	Patients were administered a total of 48 hours (1 hr sessions, 3 times a week for 16 weeks) of transcutaneous functional electrical stimulation therapy during task-oriented activities for reaching and grasping	Primary Outcomes: Rehabilitation Engineering Laboratory Hand Function Test, Quality of Upper Extremity Skills Test. Assessment time points: Baseline and discharge.	All patients significantly improved their hand function on three of subtests of the Rehabilitation Engineering Laboratory Hand Function Test (object manipulation: p=0.042, instrumented cylinder: p=0.068, and wooden blocks: p=0.068). Patients also significantly improved on the grasp component of Quality of Upper Extremity Skills Test (p=0.068).

Study/Type	Quality Rating	Sample Description	Method	Outcomes	Key Findings and Recommendations
Mirror Therapy					
Gygax, Schneider, and Newman 2011 **Switzerland** **RCT-Crossover**	CA: ☒ Blinding: Patients ☒ Assessors ☑ ITT:☒	10 children with hemiplegia (Age 6 years to 14 years, 50% male). **Inclusion criteria:** The presence of spastic hemiparesis affecting the upper limb and a normal cognitive function (Wechsler Intelligence Scale for Children >70 or ability to follow mainstream school). **Exclusion criteria:** Children who had surgery or botulinum toxin injections to the upper limb during the previous 4 months and those with hemianopsia.	Participants were randomized to either 1) bimanual training with a mirror for 15 minutes daily for 3 weeks, or 2) bimanual training without a mirror for three weeks. Participants switched to the alternate condition after three weeks.	**Primary Outcomes:** Shriner's Hospital Upper Extremity Evaluation (SHUEE) which measured maximal grasp strength, pinch strength and upper limb dynamic position. **Assessment time points:** baseline, 3 weeks, 6 weeks, and 9 weeks.	Grasp strength improved significantly with training behind the mirror (p=0.004) and with the mirror (p=0.033). Upper limb dynamic position improved significantly with a mirror (p=0.044). Training without a mirror significantly improved pinch strength (p=0.026).
Constraint-Induced Movement Therapy					
Taub et al. 2011 **USA** **RCT**	CA: ☒ Blinding: Patients ☒ Assessors ☒ ITT:☒	20 children with congenital hemiparesis (2 years to 6 years). **Inclusion criteria:** stroke in the prenatal, perinatal or very early antenatal period, upper extremity hemiparesis, aged: 2-6 years old, no serious or recurring medical complications, living within 40 miles of the University of Alabama. **Exclusion criteria:** Too little deficit in real-world spontaneous use of the more affected upper extremity as indicated by a score >2.5 on the Pediatric Motor Activity Log, uncontrolled seizures, botulinum toxin in the upper extremity or other spasticity medication within 3 months of pre-treatment testing, no fixed contractures in the affected upper extremity and previous CIMT.	Children were randomly assigned to receive constraint-induced therapy immediately or usual and customary care for 6 months, and then were crossed over to constraint-induced therapy.	**Primary Outcomes:** Pediatric Motor Activity Log; Inventory of New Motor Activities and Programs; Pediatric Arm Function Test; Passive and Active Range of Motion.	The Immediate Constraint-Induced Therapy group had a very large increase on the Pediatric Motor Activity Log relative to the control group (p<0.0001). Gains on the Pediatric Motor Activity Log were equally large after the control group was crossed over to constraint-induced therapy (p<0.0001). There was a significant pre-post treatment increase on the Pediatric Arm Function Test (11.9% to 45.0%), after crossover to constraint-induced therapy, controls similarly had a significant increase (11.8% to 57.0%, p=0.004). The Immediate Constraint-Induced Therapy group showed significant gains in active range of motion compared to the control group (p<0.0001), after cross-over, controls showed a similar significant increase (p<0.0001). At 6-month follow-up, children in the Immediate Constraint-Induced Therapy Group continued to show larger gains than the Control group in all measures (p<0.05).

Study/Type	Quality Rating	Sample Description	Method	Outcomes	Key Findings and Recommendations
Gordon et al. 2007 **United Kingdom** **Pre-post test**	N/A	6 pediatric patients with hemiparesis after arterial ischemic stroke. Inclusion Criteria: within 1 year of stroke, impaired upper limb,	Modified constraint induced therapy was used (resting splint) for 2 hours per weekday for a duration of 4 weeks. Patients used this while participating in play and leisure activities. Patients underwent a self-control procedure where they received intervention, control and then intervention again (A-B-A design).	**Outcome Measures:** Ashworth scale, grip strength, Melbourne Assessment of Unilateral Upper Limb function, Canadian Occupational Performance Measure, Goal Attainment Scaling, Weschler Intelligence Scale. <u>Assessment time points</u>: 4 weeks before intervention, immediately before the intervention, immediately after the intervention, and 4 weeks after the end of the intervention.	Melbourne Assessment: 1 patient improved. Upper limb movement: No change. Goal attainment: All patients improved. Child and parent interviews: cited that the mCIT has been beneficial, however, challenges with being tired were noted.
Su et al. 2013 **China** **RCT Crossover**	CA: ☒ Blinding: Patients ☒ Assessors ☒ ITT:☒	10 children with cerebral palsy (Age 8 years to 14 years, 80% male). **Inclusion criteria:** Children and adolescents aged 6-17 years with a diagnosis of nonspastic cerebral palsy, with no prior experience with Partial body weight-supported treadmill training (PBWSTT).	Participants were randomly assigned to either Group I or Group II. Group I received 12 weeks of PBWSTT, a 10 week washout period, and then 12-weeks of conventional gait training. Group II received 12-weeks of conventional gait training, a 10 week washout period and then 12 weeks of PBWSTT.	**Primary Outcomes:** Gross Motor-Function Measure-66 (GMFM-66) and sub-scales of GMAE, GMFM-D and GMFM-E.	Maximum walking speed significantly increased following PBWSTT ($p<0.05$). Significant effects of training were obtained across all outcome parameters with $p<0.01$ for GMAE and $p<0.05$ for GMFM-D and GMFM-E. No significant differential carryover effects were found between PBWSTTT and conventional gait trainings (GMFM-D: $p=0.303$, GMFM-E: $p=0.307$, and GMAE: $p=0.114$).
Willis et al. 2002 **USA** **RCT Crossover**	CA: ☒ Blinding: Patients ☒ Assessors ☒ ITT:☒	25 children with chronic hemiparesis (Age 1 years to 8 years; etiology of brain lesion: stroke (n=13), cerebral malformation (n=6), trauma (n=2), and unknown (n=4)). **Inclusion criteria:** Presence of a hemiparesis >1 year, aged 1-8 years. **Exclusion criteria:** Children who could not cooperate with	Participants were randomly assigned to either the treatment group or the control group. In the treatment group (n=12), children were immediately given constraint induced movement therapy via the use of plaster cast on their unaffected arm. After 1 month, the cast was removed. In the control condition (n=13), after 6 months they were given the	**Primary Outcome:** Peabody Developmental Motor Scales (PDMS). **Assessment time points:** Baseline, 1 month follow-up, 6 months follow-up.	The treatment group had a significant increase in PDMS scores after 1 month of casting compared to the control group ($p<0.0001$). The control group when crossed over to the cast treatment had significant increases in PDMS scores ($p=0.05$).

Study/Type	Quality Rating	Sample Description	Method	Outcomes	Key Findings and Recommendations
		testing.	plaster cast for 1 month.		
Karman et al. 2003 **USA** **Case Series**	N/A	Seven children with hemiparesis (Age 9 years to 17 years, 28.6% male, time since injury: 4 weeks to 2 years). **Inclusion Criteria:** asymmetry of hand function, initiation of movement in impaired upper extremity; ability to follow simple instructions and attend to a task for 3 minutes.	All patients underwent constraint induced movement therapy (CIMT) for impaired upper extremity.	**Primary outcomes:** Actual amount of use test (AAUT): AAUT amount of use (AOU) and quality of movement (QOM). **Assessment time points:** baseline and follow-up.	All children showed improvements in their AOU and QOM scores post-intervention. 3/7 patients had significant increases in AOU (p<0.01). 4/7 patients had significant increases on the QOM (p<0.01).
Rickards et al. 2014 **USA** **Pre-Post Test**	N/A	10 children (Age 2 years to 8 years, 70% male) with motor deficits following a stroke. **Inclusion criteria:** (1) stroke in the prenatal, perinatal, or very early antenatal period confirmed by MRI studies; (2) aged 2 to 8 years; (3) no serious or recurring medical complications; and (4) living within 40 miles of the University of Alabama at Birmingham. **Exclusion criteria:** (1) ferromagnetic metals in the body; (2) surgery scheduled during the 6 months after therapy; (3) severe vision or hearing problems; (4) previous CI therapy; (5) inability to initiate wrist, finger, or thumb movement; (6) severe dystonia; (7) a score of >2.5 on the Pediatric Motor Activity Log; (8) treatment with botulinum toxin in the upper extremity or other spasticity medication within 3 months of pretreatment testing; and (9) no fixed contractures in the affected	Participants were given constraint induced therapy which consisted of intensive motor training using the technique termed shaping, for 3 hours each weekday for a 3-week period.	**Primary outcomes:** Two measures of real-world motor function, the pediatric motor activity log-revised (PMAL-R) and limb preference score of the pediatric arm function test (PAFT). **Assessment time points:** Baseline and post-intervention.	Significant improvements were seen in both the PMAL-R (p<0.001) and the PAFT (p<0.001) post-intervention.

Study/Type	Quality Rating	Sample Description	Method	Outcomes	Key Findings and Recommendations
		upper extremity that would limit activity engagement.			
Sterling et al. 2013 USA Pre-Post	N/A	10 children with congenital hemiparesis (Mean age 3 years, 3 months; 60% boys). **Inclusion criteria:** A diagnosis of congenital upper-extremity hemiparesis. **Exclusion criteria:** (1) ferromagnetic metals in the body that would prohibit undergoing an MRI; (2) scheduled surgery in the 18monthsafter therapy; (3) severe vision or hearing problems; (4) uncontrolled seizures; (5) fixed contractures in the upper extremities that would limit participation in CI therapy; (6) previous CI therapy exposure	Participants underwent constraint-induced therapy, and then magnetic resonance imaging scans.	**Primary outcomes:** Pediatric Motor Activity Log-Revised to assess spontaneous use of the more-affected arm. Longitudinal voxel-based morphometry.	Children exhibited significantly large improvements in spontaneous use of the more affected arm (p<0.001). A significant increase in gray matter volume in the sensorimotor cortex contralateral to the more-affected arm (p=0.04), and these increases were correlated with motor improvement (p=0.055).
Robotics					
Qiu et al. 2011 USA RCT	CA: ☒ Blinding: Patients ☒ Assessors ☒ ITT:☒	9 children with cerebral palsy (Age 7 years to 15 years, 88.89% male) and 9 adults with stroke (Age 42 years to 77 years, 66.67% male, Mean time since injury=23.3 months).	The children group used the robotic NJIT-RAVR system for one hour, 3 days a week for three weeks. The adult group used the NJIT-RAVR system for 90 minutes, 4 days a week for two weeks.	**Primary outcomes:** Reaching performance (sideways reach, forward reach, hand to mouth reach, and composite reach).	Both groups made significant improvements in forward reach, hand to mouth and composite reach (p=0.0426, p=0.0218, and p=0.0013). Only the children group made significant improvements in sideways reach (p=0.0005).
Ladenheim et al. 2013 USA RCT	CA: ☒ Blinding: Patients ☒ Assessors ☑ ITT:☒	31 children with cerebral palsy or acquired brain injury (Age 4 years to 16 years; 48.4% male). **Inclusion criteria:** 1) Hemiparetic upper limb with increased tone as a result of an acquired brain injury or CP injury having occurred at least 6 months prior to enrollment in the study; 2) Cognitive ability and attention to play a simple video game for 45 minutes.	Participants were randomized to two groups. Both groups received 16 one hour sessions of robot-assisted therapy (twice a week for 8 weeks) where they moved a robot handle to direct a cursor on the screen toward designated targets. One group had targets presented sequentially in clockwise fashion, in the other group targets were	**Primary outcomes:** Fugl-Meyer Assessment of Motor Function (F-M); Modified Ashworth Scale (MAS); Pediatric Evaluation of Disability Inventory (PEDI).	Both groups showed improvements in the F-M, PEDI and MAS (p<0.0001; p=0.0122; p=0.0004). However differences in these measures were not significant between groups (p=0.64, p=0.64, p=0.22).

Study/Type	Quality Rating	Sample Description	Method	Outcomes	Key Findings and Recommendations
		Exclusion criteria: 1)Uncontrolled seizure disorder; 2) Fixed contracture; 3)Botox therapy less than 4 months prior to enrollment, or beginning during the course of the study; 4) Upper extremity surgery less than 6 months prior to enrollment; 5) Participation in new therapy or research protocols during the course of the study.	presented randomly.		
Fasoli et al. 2009 **USA** **Pre-Post**	N/A	12 pediatric patients (11 of whom were within 6 months of perinatal stroke) (Age 4 years, 11 months to 12 years 6 months; 58% male) **Inclusion criteria**: upper limb hemiplegia, < moderate spasticity in upper limb, adequate mobility to perform exercises. **Exclusion criteria:** received Botox in previous 4 months.	Patients participated in robotic therapy sessions of 1 hour duration, twice a week for 8 weeks. Therapy involved a selection of central and peripheral reaching movements.	**Primary outcomes:** Quality of Upper Extremity, Skills Test (QUEST), Fugl-Meyer Assessment upper limb subtest **Secondary outcomes:** Modified Ashworth Scale, Peak isometric strength of shoulder and elbow muscles Parent questionnaire scores. <u>Assessment time points:</u> Baseline, at 4 weeks, at 8 weeks, and at a 1-month follow-up visit.	Patients experienced significant improvements in QUEST total score (F = 8.41, P=0.001, r=0.49), Fugl-Meyer Assessment (F=38.01, P<0.0005, r=0.73), Modified Ashworth Scale (F=3.47, P=0.027, r=0.31), Isometric Strength – Elbow flexion (F=3.07, P=0.041, r=0.29) and Elbow extension (F=4.76, P=0.007, r=0.35). Improvement in parent questionnaire scores were observed pertaining to "how much" and "how well" children used the paretic arm during daily functional tasks at home (P=0.001; P<0.0005 respectively).
Virtual Reality					
Green and Wilson 2012 **Australia** **Case Series**	N/A	4 pediatric patients with hemiplegia (Age 3 years, 11 months to 14 years, 4 months, 50% male). **Inclusion criteria:** <21 years of age, Agreement to keep all other interventions for the upper limb constant during the study period; and are able to attend at least three 30 minute sessions each week over a three to four week period.	All patients participated in individual virtual reality (VR)-based training consisting of 9-19, 30 minute sessions over the span of four weeks. The VR training was designed to improve upper limb function by engaging attentional and motivational processes in patients through the use of real-time augmented feedback thought to encourage motor learning.	**Primary outcomes:** System-generated measures (object placement accuracy, movement speed, movement efficiency, and response errors). Standardised measures of activities and activity limitations (Box & Blocks test (B&B); Jebsen-Taylor Test of Hand Function (JTTHF); ABILHAND-kids	For 2/4 of the patients (subjects: FA and SC) there were improvements in system generated measures. These two patients also showed improvements in activity participation measures (JTTHF, B&B, ABILHAND, and CHEQ). All patients seemed to enjoy the participating in the VR-training as evidenced by the SFQ-C.

Study/Type	Quality Rating	Sample Description	Method	Outcomes	Key Findings and Recommendations
		Exclusion criteria: Patients were excluded if they received motor therapy treatment (e.g. Botulinum Toxin or Constraint Induced Movement Therapy) in the past 6 months, or if they wore daytime splints/second skin garments during the period of the study.		questionnaire, Children's Hand Experience Questionnaire (CHEQ); Short Feedback Questionnaire adapted for children (SFQ-C).	
Dysphagia					
Morgan et al. 2012 **Australia** **Cochrane Review**	N/A	Randomised controlled trials and quasi-randomised controlled trials for children with oropharyngeal dysphagia and neurological impairment.	Examining the effectiveness of interventions for oropharyngeal dysphagia in children with neurological impairment. *Neurological impairment including stroke but population % not defined.	**Primary outcomes:** swallow functioning, presence of aspiration pneumonia or chest infection, diet consistency. **Secondary outcomes:** weight and height changes, level of participation during meals, carer stress.	Three RCTs met eligibility criteria; meta-analysis was not possible. The quality of studies in this field are a concern.

Non-Interventional Studies

Study/Type	Quality Rating	Sample Description	Method	Outcomes	Key Findings and Recommendations
Bemister et al. 2015 **Canada** **Observational**	N/A	103 parents of pediatric stroke patients: Gender: fathers=27, mothers=76; Mean age=39.2 yrs; Mean child age=7.46 yrs; Stroke severity: mild=68, moderate=31, severe=4. Parents were biological parents of children 0-18 yrs with pediatric stroke, had more than grade 9 education and able to read English.	Parents were given a range of outcome measures to determine predictors of family and parent outcomes, specifically caregiver depression and family functioning.	Primary outcomes: Hospital Anxiety and Depression Scale (HADS) Pediatric Quality of Life Inventory-Family Impact Module (PedsQL-FIM) Perceived Stress Scale (PSS) Dyadic Adjustment Scale (DAS) Alberta Perinatal Stroke Project Parental Outcome Measure (POM)	Condition severity, anxiety (HADS-A), social support, stress levels (PSS), marital quality (DAS), guilt and blame significantly predicted caregiver depression (p=0.001). Condition severity, presence of cognitive impairments, presence of behavioural impairments, social support, anxiety (HADS-A), stress levels (PSS), marital quality (DAS) significantly predicted family functioning scores (p<0.001).

Study/Type	Quality Rating	Sample Description	Method	Outcomes	Key Findings and Recommendations
Bemister et al. 2014 **Canada** **Case-Control**	N/A	Study 1 56 mothers of pediatric stroke patients (stroke severity: mild=29, moderate/severe=27) and 56 mothers of children with typical development. Mothers were biological parents of children 0-18 with pediatric stroke or typically developing. Participants were excluded if they had less than nine years of formal education or were unable to fluently read English. Study 2 56 biological parents (28 mother-father couples) of children 0-18 with pediatric stroke. Participants were excluded if they had less than nine years of formal education or were unable to fluently read English	In study 1, mothers of pediatric stroke patients were compared with mothers of children with typical development on levels of anxiety, stress, family functioning, and marital strain. In study 2, mothers and fathers were compared on their anxiety, perceived stress, marital strain, and parent and family adaption.	Study 1 primary outcomes: Hospital Anxiety and Depression Scale (HADS) Perceived Stress Scale (PSS) Pediatric Quality of Life Inventory-Family Impact Module (PedsQL-FIM) Dyadic Adjustment Scale (DAS) Kansas Marital Satisfaction Scale (KMSS) Study 2 primary outcomes: HADS PSS KMSS DAS PedsQL-FIM Alberta Perinatal Stroke Project Parental Outcome Measure (POM)	Study 1 A significant difference was observed when examining symptoms of depression between mother groups (HADS-D, p=0.002). Mothers of moderate/severe stroke patients had significantly more symptoms of depression compared to the mothers with mild (p=0.001) and typical development (p=0.01) children. The PedsQL-FIM had significant differences between mother groups on its total score (p<0.001), family functioning (p<0.001), and parent health related quality of life (HRQL) score (p=0.002). Moderate/severe mothers had significantly lower scores than mothers with mild (total score, p<0.001; family functioning, p<0.001, and parent HRQL, p<0.001) and the typically development children (total score, p<0.001; family functioning, p<0.001, and parent HRQL, p=0.004). Mothers of moderate/severe stroke patients had significantly lower KMSS scores compared to mothers of mild stroke patients (p=0.003). No significant differences were seen for the DAS. Study 2 The only significant differences between mothers and fathers were found on the HADS, where mothers had higher anxiety (HADS-A, p=0.023) and higher guilt regarding their child's condition (POM Guilt, p=0.01).
Gomes et al. 2014 **Review**		16 studies of childhood stroke (CS) Inclusion criteria: studies investigating social function / Psychological outcomes following CS,	Studies were reviewed according to domains: social interaction, social participation, social cognition, and/or nature of psychological symptoms and psychopathology.	Primary Outcomes: *Social function measures*: Vineland Adaptive Behavior Scales (VABS), the Child Behavior Checklist Social Problems Scale (CBCL), Pediatric Quality of	Key Points: Trend for parents to perceive their children as having reduced levels of social function overall, as well as diminished peer acceptance and participation.

Study/Type	Quality Rating	Sample Description	Method	Outcomes	Key Findings and Recommendations
		reported on a cohort of children; included specific details of stroke diagnosis (at least AIS or HS classifications) and included a CS group (i.e., stroke > 29 days) Demographics 14 studies had a child sample <50, 2 studies had a sample >100, Age at stroke varied, Time since stroke also varied, ranging from 1–20 years		Life Inventory (Peds QL), Child Health Questionnaire (CHQ) *Psychological status:* Kids Schedule for Affective Disorders and Schizophrenia for School-Age Children Present and Lifetime Version (KSADS-PL)	ADHD symptomatology appears to be the most common symptom post-CS. Emotional dysregulation, anxiety, and mood instability have also been reported. Overall the current CS literature suggests that children are at elevated risk of mild to severe psychosocial deficits. The range of possible deficits is wide, and includes difficulties in peer acceptance interaction, reduced social participation, as well as internalizing and externalizing behavioral symptoms. Further investigation is needed to provide information regarding rehabilitation within the psychosocial domain.
Kim et al. 2013 **USA** **Retrospective**	N/A	1145 patients were analyzed (Mean age 9.1 ±5.3). Of these cases, stroke patients represented 7.2% (n=83) of the patient population studied.	Pediatric patients analyzed based on admission diagnosis and selected based on the primary presenting diagnosis. Patients stratified into categories: orthopedic conditions, brain injury, brain tumor, pain syndrome, complex medical conditions, stroke, meningoencephalitis and spinal cord injury.	Dependent Variable: Length of Stay (LOS) of inpatient rehabilitation following incident event.	LOS Mean and 95% Confidence Interval: (25.1, 21.4–29.5) p=.005.
Kolk et al. 2011 **Case-control study**	N/A	31 pediatric patients with stroke (21 neonatal strokes, 10 childhood strokes). Inclusion criteria: Documented ischemic or hemorrhagic neonatal or childhood stroke; aged 4-10 years during the study period; and fluent in the Estonian language Mean age of stroke onset: 5.49 ± 2.49, 55% male	Pediatric stroke patients were recruited with an age-matched and sex-matched control group. Children were individually tested. Scores of subtests were standardized into z-scores to make their scales comparable. Group differences were tested using Fisher's exact test with categorical variables. Stroke groups were compared with the control children according to	Primary Outcomes: neurocognitive and neurologic outcomes of children with neonatal and childhood strokes using, a Developmental Neuropsychological Assessment battery (NEPSY) and the Neurological Paediatric Stroke Outcome Measure. Timing of Assessments: Baseline (age of stroke),	Neurological Outcomes Neonatal: Neuromotor development not impaired in 9.5% of patients. Outcomes good in 28.6% of patients, and moderately or severely impaired in 62% of patients Childhood: motor outcomes were good in 30% of the children, and moderately impaired in 70% of the children. Good performance in the Executive Domain in both stroke groups was evident. Both stroke groups performed on the same level as control children

Study/Type	Quality Rating	Sample Description	Method	Outcomes	Key Findings and Recommendations
		Mean age control patients: 7.34 ± 2.49, 55% male	covariance analysis	and at age 7 for neonatal stroke patients, at age 8 for childhood stroke patients	(p<0.001) Both stroke groups produced more incorrect responses compared with control subjects in these subtests, but no significant differences were revealed between the neonatal and childhood groups. Children with neonatal strokes performed worse on most of the language subtests, except for Speeded Naming in terms of time, where the childhood stroke group demonstrated more problems. The Sensorimotor Domain was the most impaired cognitive area for both stroke groups. Tasks in the Visuospatial Domain were more impaired in the neonatal stroke group than in the childhood stroke group. In the Learning and Memory Domain, children in both stroke groups were impaired, compared with the control subjects. Key Points: More severe impairment in neurocognitive skills was evident after neonatal strokes, and the visuospatial domain was more impaired than in children from the childhood group. Prognoses were worse after left hemisphere strokes associated with epilepsy.
Avila et al. 2010 **Observational study**	N/A	32 pediatric patients with stroke. Inclusion criteria: Patients with unilateral ischemic stroke that occurred between the perinatal period and 12 years of age.	Pediatric stroke patients were recruited from neurology services and observational speech therapy evaluations were conducted by 2 independent speech language therapists.	Primary Outcomes: Evaluate association of changes in language with the age during the event, injured side, and occurrence of epilepsy.	Side of stroke: 56% left cerebral hemisphere, 44% right cerebral hemisphere Age of lesion: 66% before age 2, 44% after age 2 Epilepsy:

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		Mean stroke age: 6 ± 4.5, 50% male	For categorical data, descriptive statistics of frequencies was used. For associations between language and its aspects and age at the time of the lesion, impaired cerebral hemisphere, and presence of epilepsy, the Fisher exact test was used. A significance level of 5% was used.		25% had epilepsy Language impairments: Phonological/syntactic impairments detected in 40.6% cases, semantic impairments, detected in 34.4%, pragmatic impairments detected in 12.5% of patients. 81% patients whose stroke had occurred before 2 years of age had altered speech. Key Points: Pediatric patients had a greater rate of changes in phonology and syntax, especially children below 2 years of age, followed by semantic changes, which were present in all age ranges. Regarding pragmatics, stroke children suffered few changes in this aspect. Evidence of persistent semantic changes is a warning for the early detection of formal learning problems.
Everts et al. 2010 Observational Study	N/A	10 pediatric patients with stroke Inclusion Criteria: Unilateral ischemic stroke in childhood (1-16 years), neurological symptoms corresponding to the unilateral focal lesions detectable in neuroimaging: time of stroke at least 18 months prior to assessment. Mean age: 14.4 ± 3.1years, 90% male	10 patients with unilateral stroke (aged 10–19 years, five left-, five right-sided lesion) and 20 healthy controls (aged 8–20 years) were recruited and completed a neuropsychological test battery and functional magnetic resonance imaging (fMRI) intended to activate predominantly right (visual search) and left-sided functional networks (language). Partial one-tailed correlations calculated for a relationship between neuropsychological test results and laterality indices. The chi-squared test used to compare number of patients with	To examine the lateralization of language and visual search after childhood stroke. Primary Outcomes: Neuropsychological assessment focused on verbal and visuospatial functions. fMRI tasks: vowel detection, a synonym task, an animal search task, and a Rey search task.	Patients demonstrated atypical lateralization of visual search functions (8/10 patients, left lateralization) more often than that of language (4/10 patients, right lateralization). Dissociation between the lateralization of productive and semantic language (4/10 patients, 1/20 controls) and between the lateralization of simple and complex visual search (3/10 patients, 3/20 controls). In patients, atypical contralateral activations occurred in the same areas that showed decreasing activation during development in healthy participants. Key Points: The lateralization of functions depends upon the cognitive function measured

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			neuropsychology scores deviating from the norm		
Rodrigues et al. 2010 **Case-control study**	N/A	29 pediatric patients with stroke. Inclusion criteria: Age < 15, treated for ischemic or hemorrhagic stroke. Mean age: 9.6 years, 55% male	An experimental group of patients were recruited (n-29) and were age and gender matched to a control group of patients (n=18). The evaluation of all children was done individually in an appropriate room, free from outside interferences.	To assess cognitive development and learning in children who have had strokes. Primary Outcomes: Cognitive development evaluated using Piaget's clinical method. Five conservation tasks (number, mass, continuous quantity, weight, and volume), two tests on object classification, and one test on object seriation were used To evaluate writing, arithmetic, and reading performances, the Brazilian school performance test was used.	Piaget 8 in the experimental group (EG) had adequate performance. All of the other children had either mild (3/23), moderate (4/23), or severe (8/23) delays .In the control group (CG), 11 children had adequate performance. The other children (12/23) had a mild delay. that the performances of children who had strokes were significantly inferior to those of the control (p=0.001 , Mann-Whitney's test) Writing, Reading, Arithmetic The school performance test showed that most of the EG had weaker performances in writing (9/18), arithmetic (12/18) and reading (10/18). The children who had strokes had performances significantly inferior (Mann-Whitney test) compared to those of the CG Key Points: Strokes impaired cognitive development and learning. It is important that children have access to educational support and cognitive rehabilitation after injury
Galvin et al. 2010 **Australia** **Cross-Sectional Cohort Study**	N/A	26 patients between the ages of 7mo and 16yr, 2mo with a diagnosis of ischemic or hemorrhagic stroke from a pediatric stroke clinic. 54% of patients were male, average age was 109.04mo (or 9.09yr) and on average 17.08mo post stroke.	Administer outcome measures during an outpatient clinic visit to identify the functional tasks that are of concern to patients and their parents.	**Outcomes**: Self-care, productivity and leisure needs and abilities (using the Canadian Occupational Performance Measure (COPM)), and occupational performance and goals (using the Perceived efficacy and goal setting system (PEGS))	Of those patients who reported having ongoing concerns following stroke (88.5%), patients and parents identified 103 goals or concerns related to self-care (44), productivity (29) and leisure (30).
Kim et al. 2009 **Observational Study**	N/A	44 pediatric stroke patients Inclusion criteria: First-ever stroke, admitted to an acute rehabilitation unit	Each case was reviewed independently by 2 authors. Physical, social, and cognitive functions were evaluated, the time required to reach each functional level was recorded	Primary Outcomes: Functional Outcomes using Modified Brunnstrom stages, Gross Motor Function Classification System, activities of daily	Brunnstrom stages: Baseline:27 patients were Brunnstrom stage 1, 8 were at stage 2, and 2 were at stage 6 at the time of Discharge: the muscle tone of 12 subjects was stage 5, and 20 subjects were stage

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		Demographics: 8.7 years (8mo–17y), 57% male	in order to assess progress from the time of stroke onset. The Student *t* test and the Wilcoxon rank-sum test were employed to determine differences between groups.	living (ADLs), swallowing, speech, and sphincter function Time of Assessment: Baseline(discharge) & 1-year follow-up	6 Speech: Baseline: 19 subjects severely impaired speech-language function, and 17 able to communicate verbally but with significant limitations Discharge: 28 patients had greater than 80% of age-adjusted communication skills at 46.3 (4–165) poststroke days Key Points: Similar to the adults, most of the functional recovery in pediatric stroke occurs within the first 2 to 3 months after stroke, but the quality of functional recovery was better in the pediatric population
Everts et al. 2008 **Switzerland** **Observational**	N/A	21 patients, 0-18 years old (mean age 11.1 ±4.3, 71.4 % male).	A retrospective review of medical records in Bern and Berlin detected children who had suffered stroke in their childhood. 21 children and young adults were recruited. These subjects underwent a neuropsychological assessment to determine outcomes.	To identify cognitive, motor, and behavioral outcome after childhood stroke and to determine the effect of variables such as age at time of stroke, time elapsed since stroke, lateralization, location/size of lesion, and presence of seizure on outcomes.	Mean age at time of stroke: 7;3 y (*SD* 4;6y, range 0;1–17;6y). Mean time elapsed since stroke: 4;9 y (*SD* 3;10y, range 14 days−14;0 y). More patients showed deficits in various cognitive domains than expected from a healthy population (Performance IQ $p = .000$; Digit Span $p = .000$, Arithmetic's $p = .007$, Divided Attention $p = .028$, Alertness $p = .002$). Verbal IQ was significantly better than Performance IQ in 13 of 17 patients, independent of the hemispheric side of lesion. Certain aspects of quality of life were reduced (autonomy $p = .003$; parents' relation $p = .003$; social acceptance $p = .037$). Mean values of motor functions of patients were slightly impaired (sequential finger movements $p = .001$, hand alternation $p = .001$, foot tapping $p = .043$).

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					Lesion that occurred in the midst of childhood (5–10 years) led to better cognitive outcome than lesion in the very early (0–5 years) or late childhood (10–18 years).
Hurvitz et al. 2004 **Observational study**	N/A	29 pediatric patients with stroke Inclusion criteria: Age 3 months - 18 years, diagnosis of cerebral aneurysm, cerebrovascular accident or hemiparesis. Mean age: 19.3 ± 6.6 years	Pediatric patients with stroke were recruited via telephone and letter for consent. Demographic information was collected and qualitative surveys were sent to participants to analyze levels of adaptive behavior and quality of life. Analysis of variance (ANOVA) and student t tests were used to examine correlations between hypothesized risk factors and outcome information.	Primary Outcomes: To examine functional outcomes, predictors of functional outcomes, and the medical/functional correlates of subjective quality of life. Measures: Vineland Adaptive Behavior Scales (VABS), Diener Satisfaction with Life Scale Time of Assessment: Baseline, 5-6 years post stroke	Key Points: 96.5 % of patients finished high school, and the majority of participants had gone to college. 60% of patients over age 16 were employed Average VABS levels for communication, daily living skills, socialization, and adaptive behavior fell into the moderately low range. Use of seizure medications and ADL dependence were the predictors for lower VABS levels (p <.05). Younger age, ischemic stroke, and previous dependence in mobility were risk factors for lower scores for the self-care domain, but not for lower life satisfaction. Patients who scored below adequate on VABS tended toward lower life satisfaction.
Dumas et al. 2001 **USA** **Prospective Observational**	N/A	18 pediatric stroke patients admitted to pediatric inpatient rehabilitation Mean age 8 ± 4.1 (50% male) Length of Stay 67.1 ± 6.4	Patients were recruited from neurology inpatient units. The PEDI domain was administered at admission and at discharge. The domain had 6 classification levels with corresponding scores. Level 1: Early Feeding Level 2: Early Participation in Self Care Level 3: Early Dressing Level 4: Toileting / Dressing Level 5: Advanced Grooming	**Outcomes:** To determine functional gains by pediatric stroke patients using the Pediatric Evaluation of Disability Inventory (PEDI) Functional Skills Self-Care domain. Assessment time points: Inpatient Rehabilitation Admission and Discharge.	Admission PEDI level/score: Level II / 35.8 ± 27.4 (p=0.05) Discharge PEDI level/score: Level IV / 58.4 ± 25.2 (p=0.05) Change in PEDI level/score: +2 / +22.6 (p=0.05)

Study/Type	Quality Rating	Sample Description	Method	Outcomes	Key Findings and Recommendations
			/ Dressing Level 6: Advanced Self-care Paired t-tests were used to analyze differences between admission and discharge scores.		
Hurvitz et al. 1999 **USA** **Retrospective Cohort Study**	N/A	73 patients between the ages of 1mo and 18yr, with a diagnosis of cerebral aneurysm, cerebrovascular accident, or hemiparesis admitted to a tertiary care hospital. 60% of patients were male, average age was 8yr (range 7mo to 17yr and 8mo), 38% of patients had congenital heart disease, congenital vascular malformation, or haematological risk factors.	A retrospective review of patient charts over a 10yr period. Information was obtained from progress and therapy notes, discharge summaries and diagnostic reports.	**Outcomes**: Functional outcome (ability to perform ADLs and mobility skills), speech and language deficits, medical complications, stroke recurrence, etiologic factors, and type of stroke. Outcomes were assessed at discharge and on average 70mo after discharge.	**Rehabilitation utilization:** 44% were admitted to an inpatient rehabilitation unit with an average length of stay of 76.7d (range 9–215). **Functioning at discharge:** *Mobility skills*: 52% were independent. Speech and language difficulties in 44% of patients. *ADLs*: 64% were independent. **At follow-up:** *Mobility skills*: 84% were independent. Speech and language difficulties persisted in 40% of patients. *ADLs*: 76% were independent. *Risk factors for dependence in ADLs: female (p=0.02), younger age (p=0.03), congenital heart disease (p=0.03), hemiparesis (p=0.01) + embolic/thrombotic etiology and speech problems at presentation together accounted for 47% of the variance in ADL dependence. Seizures were present in 40% of patients Stroke recurrence occurred in 14% of patients. **Lost to follow-up:** 6 patients passed away, 2 did not consent to be interviewed and 15 were unable to be located.
Lynch 2001 **USA**	N/A	Patients with cerebrovascular disorders: arterial ischemic stroke (AIS), hemorrhagic stroke (HS), cerebral venous	Evaluation of the epidemiology of these cerebrovascular disorders in a pediatric population.	Incidence, risk factors, functional outcome and recurrence.	*AIS* Incidence rates ranges from 0.6 to 7.9 per 100,000 children, and re-hospitalization rates of 7.8 per 100,000 children per year.

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Review		thrombosis (CVT) between 30 days and 18 years of age.			Most common risk factors are cardiac disorders, hematologic disorders, metabolic disorders, vascular disorders and infection. Cardiac disorders account for 50% of AIS strokes. Blood disorders second most common risk factor where 22% of children with sickle cell disease have a silent infarction and 10% will develop a symptomatic stroke. Vascular disorders identified in 23% of children with AIS. Prevalence of AIS in children with bacterial meningitis has been reported as 27%, and 6500-15,000 children with varicella. At the outcome evaluation period of AIS patients, 35% of children were neurologically normal, 55% developed cognitive or motor problems, and 10% died before the evaluation period. Recurrence rate ranges from 6% to 30%, and develop within the first 6 months. *HS* Incidence rates ranges from 1.5 to 5.1 per 100,000 children, and re-hospitalization rates were 1.5 to 6.4 per 100,000 children. Common risk factors are vascular malformations, aneurysms, blood disorders and intracranial tumours. Vascular malformations range from 20% to 85% of children with HS. Around 1% to 2% of aneurysms result in HS. Blood disorders have been identified in 10% to 30% of children with HS. Intracranial tumours were identified in 2% to 25% of children with HS. At the outcome evaluation period of HS

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					patients, 38% of children were neurologically normal, 41% developed cognitive or motor problems, and 20% died before the evaluation period. *CVT* Incidence rates ranges from 0.4 to 0.6 per 100,000 children.
Lynch and Nelson 2001 **USA** **Review**	N/A	Patients with ischemic stroke from either: perinatal stroke (between 28 weeks gestation and 7 days of age) or neonatal stroke (>28 days of age).	Evaluation of the epidemiology of perinatal and neonatal stroke.	Incidence, risk factors, functional outcome and recurrence.	The incidence of neonatal stroke for infants more than 31 weeks of age is estimated to be 1/4000 live births. The incidence of perinatal stroke for infants less than 30 days of age is estimated to be 26.4/100,000 live births (hemorrhagic: 6.7/100,000 live births; ischemic: 17.8/100,000 live births). Mortality rates from stroke in infants greater than 30 days are estimated to be 5.33/100,000 live births (perinatal: 2.2/100,000 and neonatal: 3.49/100,000). Mortality rates from stroke in infants less than 30 days of age was 2.67/100,000 live births. Risk factor include cardiac disorders, blood disorders, infection, trauma, drugs, maternal and placental disorders, and perinatal asphyxia. Cardiac disorders present in 25% of children with ischemic stroke. At the outcome evaluation period of perinatal stroke patients, 40% were neurologically normal, 57% developed cognitive or motor problems, and 3% died before the evaluation period. Recurrence rates of neonatal stroke are 3

Study/Type	Quality Rating	Sample Description	Method	Outcomes	Key Findings and Recommendations
					to 5%.

Outcome Measure Studies

Study/Type	Quality Rating	Sample Description	Method	Outcomes	Key Findings and Recommendations
Bemister et al. 2014 **Canada** **Observational**	N/A	110 parents of pediatric stroke patients: fathers=28, mothers=82. 84 stroke patients: males=37, females=47; Stroke severity: mild=53, moderate=26, severe=5. Parents were biological parents of children 0-18 yrs with pediatric stroke, had more than grade 9 education and able to read English.	Parents were administered the Alberta Perinatal Stroke Project Parental Outcome Measure (POM), a 26-item questionnaire examining the impact of pediatric stroke on parents and families. Parents' responses were assessed at time of submission and at a 2 week follow-up.	Primary outcome: POM's internal consistency, test-retest reliability, validity, and factor structure.	POM has excellent internal consistency (Chronbach α=0.91). The POM total score demonstrated very good reliability (r=0.87) across 2-5 weeks, while the subscales demonstrated good to very good reliability (r=0.8-0.87). The POM had significant correlation for the factors: psychological impact, guilt and blame with the Pediatric Quality of Life Inventory-Family Impact Module (PedsQL-FIM), Parent Experience of Child Illness (PECI), Hospital Anxiety and Depression Scale (HADS), and Perceived Scale Stress (PSS) outcome measures (p<0.001).

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