**Figure 1.** Flow of patients

Diagram

Description automatically generated

**Table 1.** Baseline data

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | Characteristic | Overall,  N = 3841, 2 | Dyskinetic CP,  N = 581 | Hemiparetic CP,  N = 521 | Mixed CP,  N = 1101 | Spastic Diplegia,  N = 701 | Spastic Quadriplegia,  N = 921 | | --- | --- | --- | --- | --- | --- | --- | | Age, months | 78 (38) | 93 (42) | 72 (41) | 82 (37) | 66 (27) | 77 (41) | | Male | 251 (65%) | 50 (86%) | 36 (69%) | 77 (70%) | 30 (43%) | 56 (61%) | | Gestational age |  |  |  |  |  |  | | Mean (SD) | 37(4) | 38(3) | 37(4) | 38(2) | 33(3) | 38(3) | | Term | 231(60%) | 43(74%) | 32(62%) | 81(74%) | 7(10%) | 66(72%) | | Moderate to late preterm | 97 (25%) | 13 (22%) | 11 (21%) | 25 (23%) | 29 (41%) | 19 (21%) | | Very preterm | 48 (13%) | 1 (1.7%) | 7 (13%) | 4 (3.6%) | 31 (44%) | 5 (5.4%) | | Extremely preterm | 8 (2.1%) | 1 (1.7%) | 2 (3.8%) | 0 (0%) | 3 (4.3%) | 2 (2.2%) | | Mode of delivery |  |  |  |  |  |  | | Vaginal | 241 (63%) | 36 (62%) | 39 (75%) | 58 (53%) | 49 (70%) | 58 (63%) | | LSCS | 130 (34%) | 21 (36%) | 13 (25%) | 46 (42%) | 21 (30%) | 28 (30%) | | Instrumental | 13 (3.4%) | 1 (1.7%) | 0 (0%) | 6 (5.5%) | 0 (0%) | 6 (6.5%) | | Birth Weight, grams | 2,343 (796) | 2,715 (709) | 2,300 (880) | 2,563 (582) | 1,451 (439) | 2,548 (752) | | Etiology/ Risk Factors | | | | | | | | Antenatal factors | 32 | 0 | 10 | 9 | 4 | 7 | | Genetic | 23 (6.0%) | 0 (0%) | 10 (19%) | 3 (2.7%) | 1 (1.4%) | 7 (7.6%) | | Intrauterine infections | 9 (2.3%) | 0 (0%) | 0 (0%) | 6 (5.5%) | 3 (4.3%) | 0 (0%) | | Birth related factors | 320 | 58 | 40 | 82 | 66 | 74 | | Hypoglycemia | 102 (26.6%) | 0 (0%) | 0 (0%) | 61 (55%) | 0 (0%) | 41 (45%) | | Perinatal asphyxia | 90 (23.4%) | 35 (60%) | 7 (13%) | 14 (13%) | 7 (10%) | 27 (29%) | | Prematurity | 81 (21.1%) | 2 (3.4%) | 11 (21%) | 3 (2.7%) | 59 (84%) | 6 (6.5%) | | Neonatal sepsis | 74 (19.3%) | 7 | 0 | 35 | 10 | 22 | | Neonatal jaundice | 24 (6.3%) | 21 (36%) | 0 (0%) | 3 (2.7%) | 0 (0%) | 0 (0%) | | Perinatal stroke | 23 (6.0%) | 0 (0%) | 22 (42%) | 1 (0.9%) | 0 (0%) | 0 (0%) | | Birth trauma | 17 (4.4%) | 4 (6.9%) | 1 (1.9%) | 2 (1.8%) | 1 (1.4%) | 9 (9.8%) | | Etiological factors after neonatal period | 26 | 0 | 0 | 17 | 0 | 9 | | Febrile encephalopathy | 13 (3.9%) | 0 (0%) | 0 (0%) | 10 (9.1%) | 0 (0%) | 3 (5.4%) | | Surgery related hypoxia | 11 (2.9%) | 0 (0%) | 0 (0%) | 7 (6.4%) | 0 (0%) | 4 (4.3%) | | Traumatic brain injury/ drowning | 2 | 0 | 0 | 0 | 0 | 2 | | Unknown | 6 (1.6%) | 0 (0%) | 2 (3.8%) | 2 (1.8%) | 0 (0%) | 2 (2.2%) |   1Mean (SD); n (%) |
| 2Two patients from the cohort could not be classified into any of sub-categories.  \* One patient with intrauterine infection also had neonatal sepsis and later developed mixed CP  Abbreviations: CP: cerebral palsy; LSCS: lower segment caesarean section; |

**Table 2.** Prevalence of comorbidities among children with cerebral palsy

| Characteristic | Overall,  N = 3841, 2 | | Dyskinetic CP,  N = 581 | | Hemiparetic CP,  N = 521 | | Mixed CP,  N = 1101 | | Spastic Diplegia,  N = 701 | | Spastic Quadriplegia,  N = 921 | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Functional status** |  | |  | |  | |  | |  | |  | |
| GMFCS |  | |  | |  | |  | |  | |  | |
| 1 | 30 (7.8%) | | 0 (0%) | | 27 (52%) | | 0 (0%) | | 3 (4.3%) | | 0 (0%) | |
| 2 | 59 (15%) | | 2 (3.4%) | | 18 (35%) | | 2 (1.8%) | | 35 (50%) | | 2 (2.2%) | |
| 3 | 56 (15%) | | 11 (19%) | | 2 (3.8%) | | 9 (8.2%) | | 29 (41%) | | 5 (5.4%) | |
| 4 | 65 (17%) | | 19 (33%) | | 5 (9.6%) | | 24 (22%) | | 3 (4.3%) | | 13 (14%) | |
| 5 | 174 (45%) | | 26 (45%) | | 0 (0%) | | 75 (68%) | | 0 (0%) | | 72 (78%) | |
| No understanding of any communication | | 137 (36%) | | 28 (48%) | | 1 (1.9%) | | 53 (48%) | | 9 (13%) | |
| Phrases understood | | 145 (38%) | | 28 (48%) | | 4 (7.7%) | | 45 (41%) | | 28 (40%) | |
| Vocabulary understood | | 102 (27%) | | 2 (3.4%) | | 47 (90%) | | 12 (11%) | | 33 (47%) | |
| Speech communication | | | | | | | | | | | | |
| No gestural communication | 178 (46%) | | 38 (66%) | | 0 (0%) | | 73 (66%) | | 4 (5.7%) | | 62 (67%) | |
| Normal verbal communication | 8 (2.1%) | | 0 (0%) | | 4 (7.7%) | | 0 (0%) | | 4 (5.7%) | | 0 (0%) | |
| Only gestural communication | 109 (28%) | | 17 (29%) | | 8 (15%) | | 34 (31%) | | 25 (36%) | | 24 (26%) | |
| Vocabulary produced with partial verbal communication | 89 (23%) | | 3 (5.2%) | | 40 (77%) | | 3 (2.7%) | | 37 (53%) | | 6 (6.5%) | |
| Visual impairment (data for 383) | | | | | | | | | | |  | |
| Visual Impairment | 357 (93%) | | 50 (86%) | | 49 (94%) | | 99 (90%) | | 68 (99%) | | 89 (97%) | |
| Impaired Visual acuity | 246 (64%) | | 29 (50%) | | 27 (52%) | | 71 (65%) | | 52 (74%) | | 66 (72%) | |
| Refractive error | 94 (25%) | | 6 (10%) | | 13 (25%) | | 37 (34%) | | 14 (20%) | | 24 (26%) | |
| Squint | 150 (39%) | | 14 (24%) | | 19 (37%) | | 45 (41%) | | 25 (36%) | | 47 (51%) | |
| Fundus abnormalities | 293 (76%) | | 47 (81%) | | 35 (67%) | | 79 (72%) | | 54 (77%) | | 77 (84%) | |
| Abnormal VEP | 248 (72%) | | 22 (42%) | | 18 (44%) | | 79 (77%) | | 53 (88%) | | 74 (86%) | |
| Abnormal BERA | 113 (30%) | | 36 (62%) | | 2 (3.8%) | | 35 (32%) | | 14 (20%) | | 25 (27%) | |
| Social Quotient, Mean (SD) | 32 (29) | | 20 (21) | | 71 (22) | | 15 (14) | | 59 (24) | | 15 (15) | |
| Normal | 43 (11%) | | 3 (5.2%) | | 23 (44%) | | 1 (0.9%) | | 15 (22%) | | 1 (1.1%) | |
| Borderline | 10 (2.6%) | | 0 (0%) | | 5 (9.6%) | | 0 (0%) | | 5 (7.2%) | | 0 (0%) | |
| Mild | 41 (11%) | | 1 (1.7%) | | 11 (21%) | | 2 (1.8%) | | 24 (35%) | | 3 (3.3%) | |
| Moderate | 49 (13%) | | 10 (17%) | | 10 (19%) | | 8 (7.3%) | | 17 (25%) | | 4 (4.3%) | |
| Severe | 43 (11%) | | 6 (10%) | | 3 (5.8%) | | 20 (18%) | | 3 (4.3%) | | 11 (12%) | |
| Profound | 198 (51%) | | 38 (66%) | | 0 (0%) | | 79 (72%) | | 5 (7.2%) | | 73 (79%) | |
| Dental caries | 182 (48%) | | 25 (43%) | | 31 (60%) | | 53 (48%) | | 45 (64%) | | 28 (30%) | |
| Difficulty in biting | 204 (53%) | | 32 (55%) | | 6 (12%) | | 75 (68%) | | 23 (33%) | | 66 (72%) | |
| Insufficient chewing | 202 (52%) | | 36 (62%) | | 3 (5.8%) | | 76 (69%) | | 20 (29%) | | 65 (71%) | |
| Persistent drooling | 217 (57%) | | 38 (66%) | | 14 (27%) | | 70 (64%) | | 29 (41%) | | 65 (71%) | |
| Lack of appetite | 105 (27%) | | 18 (31%) | | 0 (0%) | | 36 (33%) | | 12 (17%) | | 38 (41%) | |
| Swallowing difficulties | 205 (53%) | | 33 (57%) | | 11 (21%) | | 62 (56%) | | 25 (36%) | | 72 (78%) | |
| Nasal regurgitation | 42 (11%) | | 9 (16%) | | 3 (6.2%) | | 20 (18%) | | 0 (0%) | | 10 (11%) | |
| Coughing while feeding | 140 (36%) | | 35 (60%) | | 3 (5.8%) | | 43 (39%) | | 10 (14%) | | 47 (51%) | |
| Vomiting | 50 (13%) | | 8 (14%) | | 0 (0%) | | 6 (5.5%) | | 11 (16%) | | 24 (26%) | |
| Abdominal pain/ colic | 56 (15%) | | 8 (14%) | | 0 (0%) | | 13 (12%) | | 12 (17%) | | 23 (25%) | |
| ≥2 episodes of wheezing requiring hospitalization | 83 (22%) | | 11 (19%) | | 5 (9.6%) | | 23 (21%) | | 14 (20%) | | 29 (32%) | |
| Bowel frequency |  | |  | |  | |  | |  | |  | |
| >3 times a week | 25 (6.5%) | | 7 (12%) | | 2 (3.8%) | | 2 (1.8%) | | 1 (1.4%) | | 11 (12%) | |
| 2-3 times a week | 109 (28%) | | 20 (34%) | | 4 (7.7%) | | 49 (45%) | | 12 (17%) | | 24 (26%) | |
| ≤1 times a week | 250 (65%) | | 31 (53%) | | 46 (88%) | | 59 (54%) | | 57 (81%) | | 57 (62%) | |
| Meal duration (minutes per meal) | 38 (18) | | 39 (20) | | 25 (10) | | 39 (20) | | 35 (12) | | 44 (17) | |
| Overall GI dysfunction |  | |  | |  | |  | |  | |  | |
| Normal | 88(23%) | | 7 (12%) | | 38 (73%) | | 6 (5.5%) | | 34 (49%) | | 3 (3.3%) | |
| Mild dysfunction | 72(19%) | | 19 (33%) | | 12(23%) | | 9 (8.2%) | | 23 (33%) | | 9 (9.8%) | |
| Moderate dysfunction | 134 (35%) | | 12 (21%) | | 1 (1.9%) | | 58 (53%) | | 13 (19%) | | 49 (53%) | |
| Severe dysfunction | 90 (23%) | | 20 (34%) | | 1 (1.9%) | | 37 (34%) | | 0 (0%) | | 31 (34%) | |
| **Pain** |  | |  | |  | |  | |  | |  | |
| Significant pain | 230 (60%) | | 37 (64%) | | 9 (17%) | | 88 (80%) | | 22 (31%) | | 72 (78%) | |
| **Epilepsy** |  | |  | |  | |  | |  | |  | |
| Epilepsy | 245 (64%) | | 27 (47%) | | 24 (46%) | | 88 (80%) | | 24 (34%) | | 81 (88%) | |
| Age of onset of seizures | 8 (15) | | 4 (14) | | 17 (21) | | 7 (16) | | 16 (23) | | 5 (8) | |
| Types of seizures |  | |  | |  | |  | |  | |  | |
| Generalized seizures | 119 (31%) | | 13 (22%) | | 13 (25%) | | 48 (44%) | | 7 (10%) | | 38 (41%) | |
| Focal seizures | 120 (31%) | | 23 (40%) | | 22 (42%) | | 33 (30%) | | 13 (19%) | | 28 (30%) | |
| Multifocal seizures | 225 (59%) | | 26 (45%) | | 15 (29%) | | 85 (77%) | | 18 (26%) | | 80 (87%) | |
| Myoclonic seizures | 157 (41%) | | 18 (31%) | | 2 (3.8%) | | 61 (55%) | | 7 (10%) | | 68 (74%) | |
| Drug resistant epilepsy | 163 (42%) | | 17 (29%) | | 7 (13%) | | 67 (61%) | | 6 (8.6%) | | 65 (71%) | |
| West syndrome | 145 (38%) | | 18 (31%) | | 2 (3.8%) | | 61 (55%) | | 7 (10%) | | 56 (61%) | |
| Lennox Gastaut syndrome | 128 (33%) | | 14 (24%) | | 0 (0%) | | 61 (55%) | | 5 (7.1%) | | 47 (51%) | |
| Seizure free for 2 years | 22 (5.7%) | | 2 (3.4%) | | 3 (5.8%) | | 6 (5.5%) | | 7 (10%) | | 4 (4.3%) | |
| **Sleep related comorbidities** | | | | | | | | | | | | |
| Sleep impairment | 176 (60.7%) | | 38 (66%) | | 8 (15%) | | 70 (64%) | | 6 (8.6%) | | 54 (59%) | |
| Bedtime resistance | 28 (9.7%) | | 12 (21%) | | 8 (15%) | | 5 (4.5%) | | 3 (4.3%) | | 0 (0%) | |
| Sleep onset delay | 126 (43.4%) | | 37 (64%) | | 13 (25%) | | 53 (48%) | | 7 (10%) | | 16 (17%) | |
| Impaired sleep duration | 102 (35.2%) | | 34 (59%) | | 11 (21%) | | 36 (33%) | | 10 (14%) | | 11 (12%) | |
| Sleep anxiety | 40 (13.8%) | | 23 (40%) | | 7 (13%) | | 6 (5.5%) | | 2 (2.9%) | | 2 (2.2%) | |
| Night waking | 106 (36.6%) | | 36 (62%) | | 11 (21%) | | 39 (35%) | | 6 (8.6%) | | 14 (15%) | |
| Parasomnia | 8 (2.8%) | | 2 (3.4%) | | 5 (9.6%) | | 0 (0%) | | 1 (1.4%) | | 0 (0%) | |
| Sleep disordered breathing | 80 (27.6%) | | 21 (36%) | | 5 (9.6%) | | 29 (26%) | | 5 (7.1%) | | 20 (22%) | |
| Day time sleepiness | 106 (36.6%) | | 25 (43%) | | 5 (9.6%) | | 44 (40%) | | 3 (4.3%) | | 29 (32%) | |
| Internalizing score ≥84th centile | 132 (34%) | | 23 (40%) | | 6 (12%) | | 53 (48%) | | 14 (20%) | | 34 (37%) | |
| Externalizing score ≥84th centile | 70 (18%) | | 12 (21%) | | 15 (29%) | | 17 (15%) | | 13 (19%) | | 13 (14%) | |
| Total score ≥ 84th centile | 165 (43%) | | 29 (50%) | | 17 (33%) | | 57 (52%) | | 21 (30%) | | 39 (42%) | |
|  |  | |  | |  | |  | |  | |  | |

**Table 3.** Univariable analysis of risk of comorbidities based on diagnosis and GMFCS

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Variable** | **Odds Ratio (95% Confidence Interval)** | | | | | | **p** |
| *Regression analysis, based on underlying type of CP, with reference to hemiparetic CP* | | | | | | | |
| **Type of Cerebral palsy** | **Hemiparetic CP** | **Spastic Diplegia** | **Dyskinetic CP** | **Mixed CP** | **Spastic quadriplegia** |  | |
| GMFCS | Reference | 24.1  (7.68, 107) | >2.5 x 109  (0, Inf) | >2.5 x 109  (0, Inf) | >2.5 x 109  (0, Inf) | <0.001 | |
| Social quotient | -11  (-18, -4.4) | -51  (-58, -44) | -55  (-61, -49) | -55  (-62, -49) | <0.001 | |
| Visual impairment | 4.16  (0.52, 85.5) | 0.38  (0.08, 1.41) | 0.55  (0.12, 1.86) | 1.82  (0.33, 10.1) | 0.018 | |
| Hearing impairment | 6.25  (1.64, 41.1) | 40.9  (11.2, 266) | 11.7  (3.35, 73.9) | 9.47  (2.65, 60.6) | <0.001 | |
| Speech comprehension and communication | 10.5  (4.04, 33.2) | 263  (59.9, 1964) | 76.8  (27.7, 258) | 98.7  (33.3, 357) | <0.001 | |
| Epilepsy | 0.61  (0.29, 1.27) | 1.02  (0.48, 2.16) | 4.67  (2.30, 9.70) | 8.59  (3.83, 20.5) | <0.001 | |
| Drug resistant epilepsy | 0.81  (0.22, 2.92) | 4.13  (1.31, 14.1) | 7.75  (2.93, 22.5) | 9.87  (3.64, 29.5) | <0.001 | |
| GI Dysfunction | 0.61  (0.26, 1.37) | 0.62  (0.26, 1.42) | 3.37  (1.32, 8.85) | 2.77  (1.08, 7.30) | <0.001 | |
| Pain | 1.99  (0.84, 5.00) | 7.63  (3.21, 19.7) | 17.3  (7.61, 43.2) | 15.6  (6.74, 39.5) | <0.001 | |
| Sleep impairment | 0.46  (0.14, 1.46) | 10.7  (4.01, 31.4) | 13.9  (5.60, 38.0) | 14.0  (5.41, 40.1) | <0.001 | |
| Internalizing score | 1.92  (0.71, 5.78) | 5.04  (1.95, 14.9) | 7.13  (3.00, 19.8) | 4.49  (1.85, 12.7) | <0.001 | |
| Externalizing behavior | 0.56  (0.24, 1.32) | 0.64  (0.26, 1.54) | 0.45  (0.20, 1.00) | 0.41  (0.17, 0.94) | 0.2 | |
| Total score on CBCL | 0.88  (0.41, 1.92) | 2.06  (0.96, 4.53) | 2.21  (1.12, 4.49) | 1.51  (0.75, 3.13) | 0.018 | |
| *Regression analysis, based on underlying type of GMFCS level, with reference to hemiparetic CP* | | | | | | | |
| **GMFCS** | **1** | **2** | **3** | **4** | **5** |  | |
| Social quotient | Reference | -14  -21, -7.7) | -38  (-44, -31) | -65  (-71, -59) | -70  (-76, -65) | <0.001 | |
| Visual impairment | 0 | 0 | 0 | 0 | - | |
| Hearing impairment | 2.52  (0.60, 17.3) | 7.19  (1.88, 47.5) | 8.97  (2.40, 58.6) | 6.94  (1.99, 43.9) | <0.001 | |
| Speech comprehension and communication | 4.36  (1.11, 29.1) | 84  (20.3, 591) | 114  (27, 813) | 159  (42.1, 1052) | <0.001 | |
| Epilepsy | 1.44  (0.54, 4.18) | 3.06  (1.17, 8.77) | 7.78  (2.98, 22.5) | 18.6  (7.57, 51) | <0.001 | |
| Drug resistant epilepsy |  |  |  |  |  | |
| GI dysfunction | 2.05  (0.77, 5.41) | 1.45  (0.56, 3.71) | 2.51  (0.94, 6.70) | 4.43  (1.81, 10.6) | 0.004 | |
| Pain | 0.60  (0.17, 2.23) | 4.73  (1.67, 15.7) | 11.2  (3.94, 37.8) | 19.4  (7.33, 61.5) | <0.001 | |
| Sleep impairment | 1.70  (0.36, 12.2) | 4.25  (1.01, 29.4) | 24.3  (5.99, 166) | 46.1  (12.1, 305) | <0.001 | |
| Internalizing score | 7.40  (1.35, 138) | 10.6  (1.98, 197) | 25.6  4.99, 470) | 20.7  (4.27, 373) | <0.001 | |
| Externalizing score | 0.73  (0.27, 1.99) | 0.71  (0.26, 1.95) | 0.38  (0.13, 1.10) | 0..39  (0.7, .99) | 0..14 | |
| Total score | 1.29  (0.51, 3.43) | 1.51  (0.60, 4.02) | 2.48  (1.01, 6.49) | 1.92  (0.85, 4.63) | 0.2 | |