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RESEARCH ARTICLE

Short-term outcome of physiotherpy and surgical treatment of obstetrical brachial plexus palsy

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Abstract

Background: Birth injury to the brachial plexus is referred to as obstetric brachial plexus palsy (OBPP). This study aimed to evaluate the clinical presentation and treatment outcomes of OBPP.

Methods: This study was conducted in the Orthopaedic and Neonatology Department at Bangabandhu Sheikh Mujib Medical University. Infants with OBPP who presented within six months were included and initially treated with physiotherapy for up to six months. There were incomplete (neuropraxia and axonotmesis) and complete (neurotmesis) injuries. If biceps power was recovered of birth (≥M3), therapy was continued for up to 18 months. If there was no significant improvement (≤M2), surgery was performed. The final outcome was assessed after 18 months using the Mallet score, the Raimondi score, and the Medical Research Council muscle grading scale.

Results: Out of 200 OBPP cases, 90% were enrolled through the outpatient department. One-fourth were identified during the neonatal period. The majority (96%) were born via vaginal delivery, with shoulder dystocia occurring in 68% of cases. Instrumental deliveries resulted in more severe injuries. Females and right-sided involvement were predominant. The overall satisfactory result with physiotherapy was observed in 65%, cases, whereas after surgery, it improved to 80%. However, when considering the upper trunk only, it approached 85% with physiotherapy and 98% after surgery (Mallet score >15, Medical Research Council grade ≥ 4, Raimondi score ≥2). For lower trunk and panplexus cases, satisfactory outcomes following physiotherapy and surgery were 41%.

Conclusion: Treatment initiated within six months have ensured nearly full recovery of most upper trunk and incomplete OBPP cases, but outcomes of severely affected lower trunk and panpalsy cases was poor.

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Key messages

Obstetric brachial plexus injury in babies leads to brachial palsy, known as obstetric brachial plexus palsy. Early detection and intervention are crucial for preventing deformity and disability. The interventions include physiotherapy, nerve repair or reconstruction, and muscle or tendon transfer as appropriate. We achieved satisfactory outcomes in 80% of cases with combined physiotherapy and surgery. Upper trunk and incomplete palsies showed better results than lower trunk and panpalsies.

Introduction

The network of nerves that transmits signals from the spinal cord (C5-T1) to the shoulder, arm, elbow, forearm, wrist, and hand is known as the brachial plexus. Obstetrical brachial plexus palsy (OBPP) is due to an injury to the brachial plexus in newborns, believed to result from mechanical forces during labour and delivery [1, 2, 3, 4]. Globally, the incidence rate ranges from 0.5 to 4 cases per 1,000 newborns [5, 6]. Multiple risk factors, notably fetal macrosomia, breech presentation, maternal diabetes, prolapsed hand, cephalic presentation with shoulder dystocia, cephalopelvic disproportion, primipara, and prolonged labour, have been identified [2, 3, 6].

The upper trunk palsies (C5,6), represent the most common anatomical pattern of OBPP, followed by extended upper trunk (C5,6,7) palsies. Isolated lower trunk palsies are often reported, while pan palsies (C5 -T1) are less so common [2, 3, 4]. Postganglionic injuries (rupture) are more prevalent than preganglionic root avulsion and are classified as neurapraxia, axonotmesis, or neurotmesis, according to Seddon's classification [2, 3, 7].

In Bangladesh, 62% of births still occur at home, and over 56% are assisted by traditional birth attendants. The incidence and prevalence of birth brachial plexus injuries in Bangladesh is not available [8]. Studies reported spontaneous recovery from neuropraxia within the first two months of life, but the percentage varies from as high as 92% to as low as 30% [9]. It is now widely recognised that the rate of recovery is lower than previously believed and that more children with neurotmesis and root avulsion injuries need early intervention and monitoring to improve their prognosis [2, 9, 10, 11]. Only 66% of affected children made a full recovery, and 10% to 15% suffered significant long-term impairment [12, 13].

There is limited research on OBPP in Bangladesh. Our primary objective was to ascertain the clinical presentation and the likelihood of spontaneous recovery through physiotherapy. Our secondary objectives were to examine the results of intra-plexus (primary) surgery, those who were not improved within six months of age with physiotherapy and also found out the improvement of deformity correction by secondary surgery.

Methods

This operational research was conducted in the Department of Orthopaedics at Bangabandhu Sheikh Mujib Medical University (BSMMU) from January 2022 to June 2024. Patients presenting with upper limb weakness due to OBBP irrespective of stage and clinical form, whether isolated or associated with other conditions such as fractures or glenohumeral dislocation, were included. We excluded lethal congenital anomalies and any other neurological or neuromuscular pathologies. A total of 200 cases of OBPP enrolled within six months of birth. The patients were collected from the neonatology (inpatients) and the hand clinic (referrals from other centres or hospitals) at the orthopaedic outpatient department in BSMMU.

Following patient enrolment, intervention (rehabilitation and surgery) and follow-ups were provided in the orthopaedic department, under the hand and reconstructive surgery division. Diagnosis was primarily clinical. The rehabilitation protocol commenced two weeks after birth and continued until six months of age. Any suspected fractures were confirmed by X-ray, after which immobilisation was done for up to three weeks. Electrodiagnosis and magnetic resonance imaging of the brachial plexus were performed exclusively in severe cases of panpalsy or when significant improvement had not been observed within three months of assessment age [1, 3, 4].

Physiotherapy

The physician first demonstrated physiotherapy to the parents, who were advised to perform the exercises regularly for a minimum of six months. The first group consists of passive, gentle, repeated, and systematic shoulder, elbow, wrist, and fingers mobilisation, irrespective of age and type of OBPP. Sessions lasting 10 to 15 minutes, conducted at least eight times per day, were encouraged. The second group of exercises, aimed at infants aged at least three months, includes engaging interactive activities with colourful toys that produced sounds and light balloons, designed to stimulate recovery through bimanual gripping. Furthermore, shoulder external rotation (airplane) splinting played an important role for those with developed shoulder adduction and internal rotation deformities. A wrist splint was recommended for those who exhibited wrist drop along with thumb adduction deformity. Those who showed satisfactory improvement in biceps function, as measured by the Medical Research Council (MRC) scale ≥M3 within six months following physiotherapy, continued with the exercise programme for up to 18 months. If satisfactory improvement in biceps function was not achieved, appropriate investigations were undertaken, and a plan for surgical treatment was formulated [2, 3, 6].

Investigations:

Electrodiagnosis, which includes nerve conduction studies and electromyography, can provide valuable clinical information, although interpreting motor unit action potentials may prove challenging. Electrodiagnosis studies can address the following questions: What location and specific segment were involved? How extensive or severe was the condition (axonotmesis or neurotmesis), and was it preganglionic or postganglionic? Magnetic resonance imaging highly sensitive in detecting lesions of the peripheral nerves was done in severe cases only. MRN was localised the site and type of lesion eighter rapture of evolution of the roots. [4, 13]

Surgical treatment

Intra-plexus (primary) microsurgical procedures **(Figure 1)**, such as neurolysis, excision of neuroma followed by nerve repair, nerve grafting, or neurotization (nerve transfer), were performed solely on those who had not recovered to a satisfactory level after 6 months of physiotherapy. Those who achieved satisfactory improvement in antigravity biceps power (≥M3) within 6 months but had some residual

Figure 1 Self-rehabilitation protocol executed by the mother
a) abduction, b) external rotation, c) elbow flexion, d) elbow extension with supination, e) wrist and finger extension, f) wrist and finger flexion. (Permission was taken from parents for using these pictures in publication)

deformities continued with physiotherapy and were planned for deformity correction (secondary surgery) through soft tissue release with muscle transfer procedures after 18 months of age (Figure 2). Michelow *et al.* assigned the indication for primary microsurgical procedures if a score of less than 3.5 out of the highest possible score of 10 was recorded. A score between 0 and 2, where 0 denotes no function, 1 denotes partial function, and 2 denotes normal function, of the five motor functions (elbow flexion, wrist, finger, thumb extensions, and shoulder abduction) is assessed after three months of age. If the score exceeds 3.5, follow-up is recommended for up to 18 months; if any functional deficiencies are noted, secondary surgical procedures are advised to correct them. Conversely, a Mallet score of less than 13 out of 25 (five functions, each rated from one to five points, including shoulder abduction, external rotation, hand to mouth, hand to neck, and hand on spine) at three months of age also indicates the need for upper plexus surgery palsy [2,3,7,14].

Follow-up

The follow-up schedule consisted of monthly visits for the first six months, followed by bi-monthly visits for a further six months, and finally, quarterly visits until 30 months. The minimum required follow-up was 18 months; however, a follow-up period of at least 36 months is necessary to properly evaluate complete panpalsy cases. Functional improvement was evaluated using different scales. Typically, upper plexus palsy cases were assessed by the Mallet score, which evaluates shoulder and elbow function. The components include global external rotation, abduction, hand-to-mouth, hand-to-neck, and hand-to-spine movements. The highest possible score is 25, with scores ranging from 14 to 25 considered satisfactory and scores from 0 to 13 deemed unsatisfactory. The Raimondi score is used to assess hand and wrist function, where scores of 0-1 are considered unsatisfactory, scores of 2-3 are viewed as satisfactory, and overall muscle strength was assessed using the MRC scale, where M≥3 was considered satisfactory and M≤2 is deemed unsatisfactory [2,3,12,13].

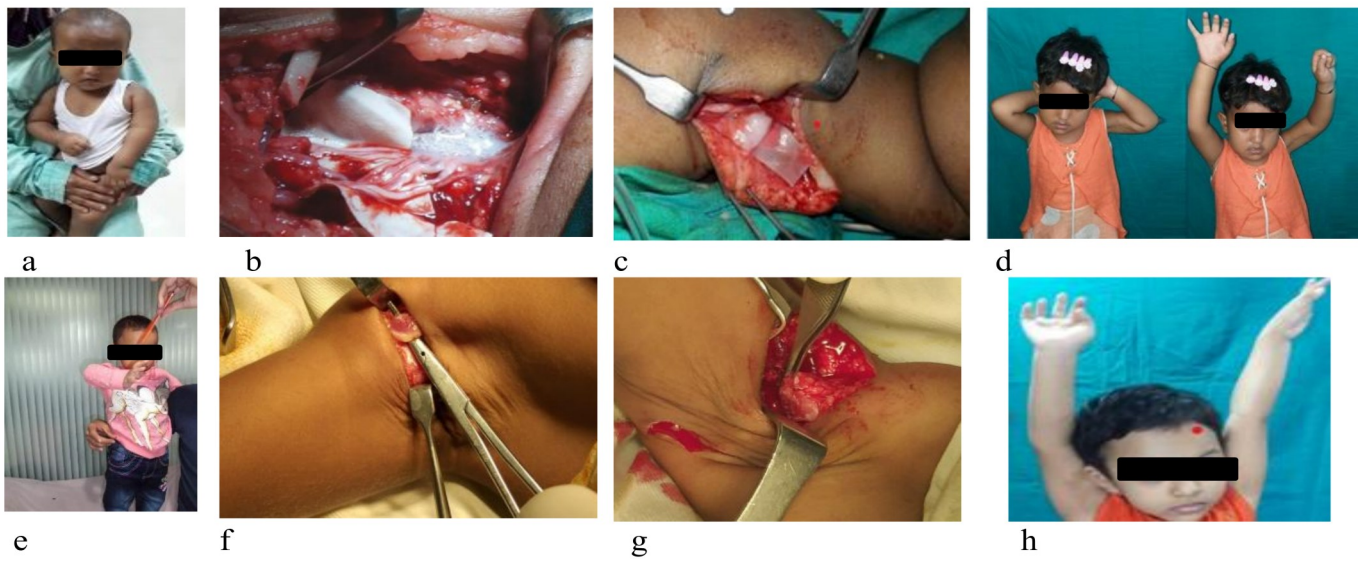

Figure 2 Primary and secondary surgeries

Upper panel: Primary surgery of a 6 months old girl, a) extended left-upper obstetrical brachial plexus (C5,6,7), b) cables nerve grafting, c) ulnar nerve fascicle transfer to biceps br. of MCN, d) excellent recovery of 24 months follow up abduction and external rotation of shoulder.

Lower panel: Secondary surgery of a 18 months old girl, e) adduction and internal rotation deformity of shoulder, f) release of pectoralis major, g) release of LD and transfer to teres minor, h) excellent recovery of 6 months follow up.

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Table 1 Background status of the enrolled cases (n=200)

Background characteristics	Number (%)
Age at presentation (weeks)[a]	14.3 (9.2)
Gestational age at birth (weeks)[a]	37.5 (2.8)
Birth weight (grams)[a]	2,975.0 (825.0)
Sex	
Male	82 (41)
Female	118 (59)
Affected side	
Right	140 (70)
Left	54 (27)
Bilateral	6 (3)
Delivery type	
Normal vaginal delivery	152 (76)
Instrumental delivery	40 (20)
Cesarean section	8 (4)
Place of delivery	
Home delivery by traditional birth attendant	30 (15)
Hospital delivery by midwife	120 (60)
Hospital delivery by doctor	50 (25)
Prolonged labor	136 (68)
Presentation	
Cephalic	144 (72)
Breech	40 (20)
Transverse	16 (8)
Shoulder dystocia	136 (68)
Maternal diabetes	40 (20)
Maternal age (years)[a]	27.5 (6.8)
Parity of mother	
Primipara	156 (78)
Multipara	156 (78)

[a]Mean (standard deviation), all others are n (%)

Ethical consideration

The therapeutic approaches employed are grounded in the standard practices of the division under the lead author (KPD). However, the procedure, risks, and benefits were explained to the patient's parents (or legal guardians), and written informed consent was obtained. Permission to disclose the patients' photo for research and publication purposes was secured. They were assured that all data would remain confidential and not be disclosed except for the education of students of the orthopaedics courses. All participants were guaranteed the full right to decline the surgical interventions.

Statistical analysis

Data analysis was performed using SPSS version 26.0. The categorical variables (sex, parity of mother, delivery type, presentation, etc.) are presented as numbers (percentages), while numerical variables (age at presentation, birth weight, etc.) were expressed as mean (standard deviation).

Results

Out of 200 enrolled cases of OBPP, 90% were referred from other centres and enrolled through the hand clinic, while the remaining 10% of cases were enrolled from the neonatology department. Only 25% of cases were identified during the neonatal period; the remaining 150 patients were enrolled within 6 months of birth injury. The mean age of presentation was 14.3 (standard deviation, 9.2) weeks, and the mean gestational age at delivery was 37.5 weeks. The mean birth weight was 2975 grams (Table 1). Twenty percent of mothers had diabetes, and their mean age was 27.6 years, with 78% being primipara. Normal vaginal delivery accounted for 76% of cases, instrumental delivery for 20%, while caesarean section delivery constituted only 4% of cases. Traditional birth attendants and midwives conducted 75% of the deliveries, whereas only 25% were carried out by doctors. Prolonged second stage of labour (68%) was the most common risk factor. Transverse presentation with shoulder dystocia (68%) was the most common presentation.

According to Narakas grading, 36% of cases were grade 1, presenting with C5,6 roots or upper trunk injury. Thirty two percent of cases were classified as grade 2 injury, with extended upper trunk involvement (C5,6,7). However, 25% of cases were identified as grade 3 injuries, which indicate pan-palsy or involvement of all five roots or trunk, while the remaining 7% were classified as grade 4, pan-palsy with Horner's syndrome. There was no substantial improvement in 40 cases (20%) (Table 2). Only in extensive injury cases where substantial improvement was not observed within six months were advised to undergo electrodiagnosis and magnetic resonance imaging studies.

Out of 40 cases with magnetic resonance imaging findings, neuroma in continuity was present in 20%, root ruptures were found in 25%, on the other hand, ruptures with avulsion were seen in 35%, and only root avulsion occurred in 20% of cases.

Overall, satisfactory rehabilitation improvement occurred in 65% of cases, mostly among those with Narakas type I and II palsy, with biceps motor recovery (M≥3) achieved within 3 months and wrist motor recovery at M≤2 level within 2 months.

Table 2 Evaluation of the rates of spontaneous (conservative treatment) recovery according to Narakas classification[b]

Narakas classification	Total 200 (100%)	Grade 1 72 (36%)	Grade 2 64 (32%)	Grade 3 50 (25%)	Grade 4 14 (7%)
Complete recovery[a]	107 (54)	60 (83)	40 (63)	7 (14)	-
Near complete functional recovery but partial deformity[a]	22 (11)	5 (7)	10 (16)	6 (12)	1 (7)
Partial recovery with gross functional defect and deformity	31 (16)	7 (10)	13 (20)	10 (20)	1 (7)
No significant improvement	40 (20)	-	1 (1.5)	27 (54)	12 (86)

[a]Satisfactory recovery

[b]Grade 1, C5, 6, 7 improvement; Grade 2, C5, 6, 7 improvement; Grade 3, panpalsy C5, 6, 7,8, 9, Grade 4, panpalsy with Hornon's syndrome.

Table 3 Satisfactory outcome of primary and secondary surgeries of obstetric brachial plexus palsies

Surgeries	Number (%)	Satisfactory outcomes n (%)
Primary surgery (n=24)		
Upper plexus	6 (25)	5 (83)
Pan-palsy	18 (75)	6 (33)
All	24 (100)	11 (46)
Secondary Surgery (n=26)		
Shoulder deformity	15 (58)	13 (87)
Wrist and forearm deformity	11 (42)	6 (54)
All	26 (100)	19 (73)
Primary and secondary surgery	50 (100)	30 (60)

Mallet score 14 to 25 or Raimondi score 2-3 or Medical Research grading >3 to 5.

Conversely, only 22% of functional improvement was observed in Narakas type III and IV injuries. Furthermore, only 10% and 20% of patients with Narakas grade 1 and grade 2 injuries demonstrated partial improvement but presented with residual shoulder adduction and internal rotation deformities, while the partial improvement rates were 20% in grade 3 and 7% in grade 4 injuries. No significant improvement was noted in 20% of cases; among these, 2.5% were in grade 2, 67.5% in grade 3, and 30% in grade 4 injuries, with no cases in grade 1 injuries. These groups exhibited upper limb (shoulder, elbow, and hand) deformities, indicating the need for early surgical intervention.

After performing the primary intra-plexus surgery (neurolysis, nerve repair, grafting, and nerve transfer), cases of upper palsy and incompletely injured individuals showed a better outcome (satisfactory results at 83%) compared to those with lower palsy or complete palsy cases (satisfactory results at only 33%) (Table 3). In secondary surgeries (Figure 3), the satisfactory result was 87% for shoulder deformity correction and 54% for wrist and forearm deformity correction. Overall, (98%) satisfactory outcomes were achieved in upper trunk palsies compared to (41%) in the lower trunk palsies.

Discussion

Two-thirds of OBPP cases showed satisfactory improvement with physiotherapy alone, and after surgery, the satisfactory improvement rate was 80%. This indicates a Mallet score for shoulder function greater than 13 out of 25, a Raimondi score of 2-3 for hand function, and an MRC grading of muscle power greater than 3 out of 5. The satisfactory improvement was much higher (98%) in the upper trunk than the lower trunk (41%), with a follow-up of at least 18 months.

The reported rates of satisfactory recovery varied from 68-95%. Narakas grade 1 (upper trunk palsy) patients had a significantly better prognosis of 90% with conservative treatment, consistent with other series. In contrast, the satisfactory recovery rates for Narakas grade 2 (extended upper trunk palsy), grade 3 (pan-palsy/lower trunk palsy), and grade 4 (pan-palsy with Horner's syndrome) were 79%, 26%, and 7% of patients, respectively, in this series, leading to an overall rate of recovery were 50% in these three groups. This is relatively lower than the spontaneous recovery rates reported in other studies, likely because BSMMU is the only tertiary care referral centre treating all types of OBPP cases, with 90% of respondents referred from other centres. Additionally, the severe forms of injuries (grades 2, 3 and 4) comprised 64% of this study subjects, compared to 20%–30% in other Western studies, which may have influenced the spontaneous recovery rate. The mean age of presentation was 14.3 weeks, which is considered too late for early management and negatively impacted outcomes. Management of OBPP should commence within 6 weeks, and passive exercises for all joints of the affected upper limb should be initiated to prevent contracture and deformity formation, enabling the regenerated nerve to grow along its previous pathway and establish a healthy motor end plate for functioning muscle. However, only 30% of cases achieved this favourable condition.

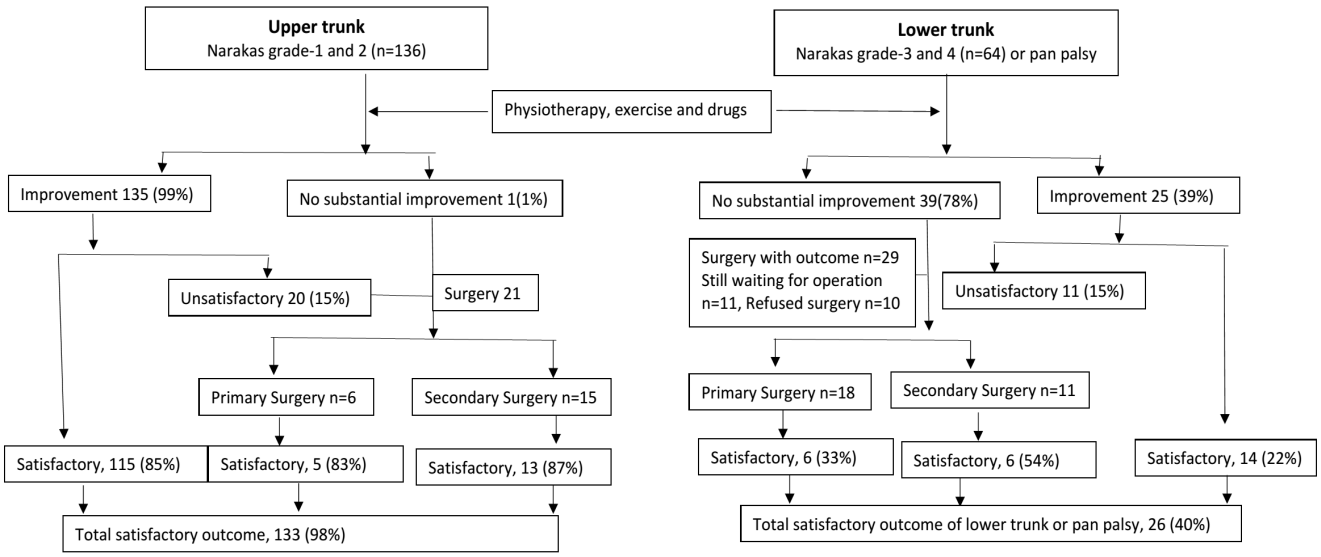

Figure 3 Flowchart of upper and lower trunk treatment outcomes

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Exploration (surgery) between the 3rd and 6th months is advised for an infant exhibiting complete involvement with Horner's syndrome [3, 15, 16, 17]. However, cases were performed between 5 and 15 months (mean 8.4 months), somewhat longer than in reputed centres [3, 12]. Even in milder forms of injury, such as Narakas type I, if biceps power does not recover to M3 level within 3 months, some degree of residual deformity, including shoulder adduction and internal rotation, results; the more extensive the lesion, the greater the severity of the deformities produced, which require correction through secondary surgery for functional improvement. Secondary surgical interventions are recommended for children older than 18 months who have shoulder abduction and external rotation limitations, causing difficulties in daily activities [3, 6, 18]. Satisfactory outcomes from primary intra-plexus surgery were better 83% in incomplete and upper plexus palsy cases, which is significant and comparable to other studies [2, 13, 14]; however, satisfactory results in pan-palsy cases were only 33%, and overall satisfactory outcomes from primary surgery were 46%, which is not statistically significant, possibly due to short follow-up and severe injury patterns, aligning with findings from other studies [3, 15]. The satisfactory results of secondary surgery for shoulder deformity correction were 85%, while wrist and hand deformity corrections achieved 54%, both of which are statistically significant. However, in severe from of injury cases, parents were not interested to do the surgery in 16% of cases due to uncertainly of results.

Most respondents were classified as infants with a birth weight exceeding 3000 g. However, the mean weight in our study children was 2975 g, which is lower than the average birth weight reported in the literature for OBPP, yet higher than the average birth weight of 2565 g in Bangladesh. It has been reported that the risk of OBPP significantly increases with vaginal delivery in infants with a birth weight above 4000 g. Shoulder dystocia and high birth weight are two risk factors strongly associated with birth injury. Furthermore, it was observed that delivering infants with higher birth weights via caesarean section reduced the frequency of OBPP. Females are affected more than males, with right-sided involvement being more prevalent than left-sided, while bilateral involvement is rare. The number of patients born at home or in primary healthcare centres, regardless of whether assisted by a midwife or not, exhibited a high incidence of OBPP, with three-quarters of our patients being delivered at home or in primary healthcare centres by traditional birth attendants. Conversely, the frequency was significantly lower in better obstetric clinics when trained professionals or doctors performed births. Panpalsy and avulsion injury were also more prevalent in the lower roots, particularly associated with transverse lie or breech presentation. Assisted labour, such as the use of forceps and ventouse, not only heightened the risk but also led to permanent injury or panpalsy, with limited chances of spontaneous recovery [2, 3]. One-fifth of our patients had a history of assisted delivery; however, two-thirds of them presented with a severe pattern of injuries, a finding that aligns with other studies [3, 4].

The management, surgical or non-surgical, was done by a single team, for the first time in Bangladesh. One-fourth cases were treated within 4 weeks of age, and nine in ten cases were referred by other centres. The referred cases had inadequate background data. Physiotherapy initially was done by physician and followed by the patients' parents. There was mix of skills to get uniform results.

Finally, early detection, rehabilitation and appropriate surgical treatment is essential for better prognosis and can be ensured near normal function for most of the patients. Excellent recovery was ensured in incomplete and upper plexus palsy cases. Early surgery, even in severe (pan-palsy) cases can prevent complications and improved the quality of life but not ensure for recovery.

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Author contributions

Conception or design of the work; or the acquisition, analysis, or interpretation of data and drafting the work: KPD, RMC. *Drafting the work or reviewing it critically for important intellectual content:* KPD, RMC, SKM, MM, MS. *Final approval of the version to be published:* KPD, RMC, SKM, MM, MS. *Accountable for all aspects of the work in ensuring that questions related to the accuracy or lintegrity of any part of the work are appropriately investigated and resolved:* KPD, RMC.

Conflict of interest

We do not have any conflict of interest.

Data availability statement

We confirm that the data supporting the findings of the study will be shared upon reasonable request.

Supplementary file

None

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