Original Investigation

Obstetric brachial plexus injury: risk factors and clinical follow-up results

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Abstract

Objective: Obstetric brachial plexus injury is a significant cause of neonatal morbidity. The aim of this study was to evaluate the maternal and perinatal factors associated with plexus injury and to analyze clinical follow-up outcomes and parental caregiving burden.

Material and Methods: This study was conducted as a retrospective descriptive study at the maternity center of a tertiary hospital. Deliveries resulting in obstetric plexus injury between February 2018 and December 2023 were included in the study. Out of 27,695 live births, 28 infants with plexus injury were identified and analyzed.

Results: Of the women who gave birth to infants with brachial plexus injury, 25 (89.3%) were aged 21-34 years, and 22 (78.6%) had a body mass index between 25 and 29.99 kg/m^2. Of the cohort, 16 (57.1%) were multiparous, and 3 (10.7%) had gestational diabetes. In addition, 15 (53.6%) women underwent labor induction, and all had vaginal deliveries. Shoulder dystocia occurred in 11 deliveries (39.3%). Of the newborns with brachial plexus injury, 25 (89.3%) had Erb's palsy. The mean follow-up period for the infants was 12 (3-31) months. Injury recovery occurred in 24 babies (85.7%), while four babies (14.3%) experienced permanent injury. Regarding parental caregiving burden, 22 parents (78.6%) reported "no to mild burden," while six parents (21.4%) reported a "mild to moderate burden." No parents reported "moderate to severe" or "severe burden". All newborns with permanent damage developed shoulder dystocia at delivery (p=0.007).

Conclusion: Most infants with plexus injury recovered, while permanent injury was linked to shoulder dystocia, and parental caregiving burden was generally low. [J Turk Ger Gynecol Assoc.]

Keywords: Birth injury, macrosomia, neonatal, newborn, shoulder dystocia

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Introduction

Obstetric brachial plexus injury (OBPI) is damage between the fifth cervical nerve root and the first thoracic nerve root during labor. These nerve roots collectively form the brachial plexus, responsible for sensory and motor functions in the shoulder and arm muscles. Manifestations of OBPI include muscle weakness, sensory disturbances, limited arm movements, and potentially the absence of the Moro reflex on the affected side (1,2). Although brachial plexus injury can occur during birth, it may also occur *in utero* before delivery. In such cases, paralysis may be accompanied by findings such as muscle atrophy and

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bone demineralization on the affected side (3). The incidence of OBPI ranges from 0.4 to 3 per 1,000 live births (4). Damage to the fifth and sixth cervical nerve roots is termed Erb (5) paralysis, damage to the eighth cervical and first thoracic nerve roots is referred to as Klumpke (6) paralysis, and damage to all nerve roots from C5 to T1 is defined as total paralysis. In the clinic, 85% of cases result in Erb paralysis and Erb palsy plus. In Erb palsy plus, additional damage to the seventh cervical nerve is involved, along with the typical involvement of C5 and C6 (7). The primary risk factor for the development of OBPI is shoulder dystocia. When shoulder dystocia complicates birth, the main mechanism causing brachial plexus damage is the application of lateral traction to the fetal head towards the posterior shoulder (8). Possible risk factors contributing to an increased occurrence of brachial plexus damage include gestational diabetes mellitus (GDM), labor induction, macrosomic fetus, multiparity, excessive maternal weight gain during pregnancy, breech presentation, and instrumental delivery (9). To prevent OBPI, obstetricians should remain vigilant for the occurrence of shoulder dystocia and be prepared to implement appropriate interventions, such as the Crede maneuver, McRoberts maneuver, and Woods maneuver, when dystocia arises. In addition, clinicians should consider risk factors, including fetal macrosomia, maternal diabetes, and a history of shoulder dystocia, which may predispose to fetal injury, when determining obstetric management strategies (10). Electrodiagnostic tools, such as electromyography and neuroradiological imaging, especially magnetic resonance, can be valuable for evaluating the severity and mapping of brachial plexus damage. While improvement is typically seen with follow-up physical and occupational therapy, if no significant progress occurs within 3 to 9 months, surgical intervention may become necessary (11,12).

The aim of this study was to assess maternal and perinatal factors associated with OBPI cases and to examine the outcomes of clinical follow-up and parental care burden.

Material and Methods

This was a retrospective descriptive study performed in the maternity center of a tertiary hospital. Deliveries resulting in OBPI between February 2018 and December 2023 were reviewed. Patient information was obtained from hospital electronic health records. Fetuses diagnosed with OBPI through newborn examinations and diagnostic methods, such as electromyography, were included in the study. Stillbirths were excluded from the study. We evaluated the characteristics of fetuses with OBPI, their clinical follow-up, recovery status, obstetric parameters of the mothers, and parental care burden. The study was conducted in accordance with the principles of the Declaration of Helsinki and informed consent was obtained from all participants. During the data collection phase, the identification numbers of pregnant women and newborns were anonymized. Mothers' age, gravida, parity, body mass index (BMI), presence of chronic disease, number of antenatal visits, serum calcium levels, gestational weeks, and delivery types were evaluated. Postnatal infants' birth weight, length, activity pulse grimace appearance respiration (APGAR) scores, gender, need for neonatal intensive care unit, and complications were examined. The incidence rates of fetuses with OBPI by year, types of brachial plexus injuries, and clinical follow-up were investigated. We also assessed the parental care burden using the Zarit scale of caregiver burden (ZCB). The ZCB scale, developed by Zarit et al. (13), assesses the psychological and social conditions of caregivers, the impact of the care recipient on the caregiver, and the economic conditions involved. The scale consists of 22 questions and is a Likert-type instrument with five response options for each question: never (0 points), rarely (1 point), sometimes (2 points), quite often (3 points), and almost always (4 points). A minimum of 0 and a maximum of 88 points can be scored on the scale. The total score interpretations are: 0-21 indicates no to mild burden; 21-40 indicates mild to moderate burden; 41-60 indicates moderate to severe burden; and ≥61 indicates severe burden. This study was approved by the Scientific Research Ethics Committee of University of Health Sciences Türkiye, Şehit Prof. Dr. İlhan Varank Training and Research Hospital (approval number: 2024/48, date: 20.02.2024). All vaginal deliveries at our obstetric center are conducted in the delivery room using the lithotomy position, following current guidelines. In cases of shoulder dystocia, appropriate standard maneuvers are promptly performed. All newborns are comprehensively evaluated by a pediatrician, both in the delivery room and in the examination room. The diagnosis of brachial plexus injury is confirmed by the pediatrician through physical examination after delivery. Following discharge and during follow-up visits, electrodiagnostic and neuroradiological assessments are performed when necessary. A consensus diagnosis and management plan are then established through collaboration between specialists in physical therapy, orthopedics, and pediatrics.

Statistical analysis

Data were statistically analyzed using the Statistical Package for the Social Sciences for Windows, v.21.0 (IBM Inc., Armonk, NY, USA). Descriptive statistical methods (mean, standard deviation, median, frequency, percentage, minimum, and maximum) were used to evaluate the study data. Categorical variables were compared using Pearson's chi-square test or Fisher's exact test, as appropriate. A p-value of <0.05 was considered statistically significant.

Results

Between 2018 and 2023, there were 27,695 births in our unit, 28 of whom were infants with OBPI. Our clinic's OBPI rate is 1.01 per 1,000 births. Table 1 shows OBPI rates by year.

Among the women who gave birth to fetuses with brachial plexus damage, 25 (89.3%) were aged 21-34 years, and 22 (78.6%) had a BMI of 25-29.99 kg/m^2. Of the women, 16 (57.1%) were multiparous, 12 (42.9%) were nulliparous, 23 (82.1%) had no additional diseases, and 3 (10.7%) had GDM. While five women (17.9%) did not attend any antenatal care visits, 19 women (67.9%) attended 1-3 visits, and four women (14.3%) attended more than four visits. The presenting symptom at hospital admission was labor pain in 12 (42.9%) women and premature rupture of membranes in 11 (39.3%) women. In addition, 15 (53.6%) women received labor induction, while 13 (46.4%) did not. The mean delivery duration was 6 (1-48) hours. Sixteen women (57.1%) gave birth ante meridiem, and 14 women (50%) underwent an episiotomy (Table 2).

The median APGAR scores of newborns born with brachial plexus injury were 8 (5-9) at the first minute and 9 (8-9) at the fifth minute. The birth weight of 10 newborns (35.7%) was between 3000-3499 grams, 13 newborns (46.4%) weighed between 3500-3999 grams, and 5 newborns (17.9%) weighed 4000 grams or more. The mean length of the newborns was 52.57±1.68 cm, and the mean head circumference was 35.11±1.28 cm. Among them, 18 (64.3%) were female, and 10 (35.7%) were male. Brachial plexus injury occurred on the right side in 22 newborns (78.6%) and on the left side in 6 newborns (21.4%). No complications were observed in 17 newborns (60.7%) after birth, while caput succedaneum was detected in 5 (17.9%), subconjunctival hemorrhage in 4 (14.3%), clavicle fracture in 1 (3.6%), and adrenal region hematoma in 1 (3.6%). Shoulder dystocia occurred in 11 (39.3%) deliveries, while it was not observed in 17 (60.7%) deliveries (Table 3).

Among newborns with brachial plexus injury, 25 (89.3%) had Erb's palsy, 2 (7.1%) had Klumpke's palsy, and 1 (3.6%) had total paralysis. The median follow-up period for the newborns was 12 (3-31) months. The injury healed in 24 (85.7%) babies, while 4 (14.3%) babies experienced permanent injury. Twenty-two parents (78.6%) reported "no to mild care burden", and six (21.4%) reported a "mild to moderate care burden". No parents were identified as "moderate to severe burden" or "severe burden" (Table 4).

There were no significant differences in maternal obesity, rates of multiparity, labor induction, or macrosomia between newborns with permanent and transient injury (p=0.497, p=0.196, p=0.356, and p=0.497, respectively). Shoulder dystocia occurred in all newborns with permanent injury, compared to 7 (29.2%) cases among those with transient injury (p=0.007) (Table 5).

Discussion

In the present study that examined the characteristics of infants born with brachial plexus injuries over a six-year period (2018-2023) at a tertiary hospital, there was an OBPI rate of 1.01 per thousand births. The review, which included 46 studies on the epidemiology of OBPI, reported rates ranging from 0.3 to 3 per 1,000 births (14). We believe that the variation in incidence rates is influenced by countries' levels of development, obstetric care practices, geographical factors, and nutritional habits. An analysis of our clinic's OBPI rates from 2018 to 2023 reveals a variable pattern, with rates alternating between increases and decreases over the years. The peak incidence was 1.91 per thousand in 2021, while the lowest was 0.46 per thousand in 2018. At our clinic, obstetric residents perform deliveries under the supervision of an obstetric specialist. Over time, experienced residents graduate and leave the hospital, while less experienced residents, who are just beginning, take on the task of performing deliveries. We think that this dynamic has influenced the changes in our clinic's OBPI rates over the years, with rates decreasing as the experience of residents performing deliveries increases.

Of the mothers who gave birth to infants with OBPI, only 10.7% were of advanced maternal age (35 years or more). Advanced maternal age may adversely affect birth outcomes. A recent study conducted in California, involving more than 8 million

Table 1. The number of infants born and the rate of obstetric brachial plexus injury

Years	Number of infants	OBPI	OBPI rate/1,000 births
2018	4394	2	0.46
2019	5471	8	1.46
2020	4666	3	0.64
2021	4717	9	1.91
2022	4328	3	0.69
2023	4119	3	0.73
Total	27695	28	1.01

Values are presented n (‰), OBPI: Obstetric brachial plexus injury

participants, found that the rate of brachial plexus injury in advanced-age mothers was 13.6%. The study also reported that the risk of OBPI increased by [aortic outflow region (AOR): 1.16] compared to mothers aged 20-34 years (15). We believe that chronic diseases, maternal exhaustion, and insufficient pushing, which become more common with advanced maternal age, contribute to the increased OBPI rates.

Table 2. Maternal and obstetric characteristics

	n=28
Maternal age (years)	
21-34	25 (89.3)
35 or more	3 (10.7)
Body mass index (kg/m^2)	
18-24.99	3 (10.7)
25-29.99	22 (78.6)
30 or more	3 (10.7)
Gravida	2 (1-6)
Parity	
Nulliparous	12 (42.9)
Multiparous	16 (57.1)
Abortions	0 (0-2)
Maternal chronic diseases	
No	23 (82.1)
Gestational diabetes mellitus	3 (10.7)
Asthma	1 (3.6)
Hepatitis B disease	1 (3.6)
Antenatal care visits	
0	5 (17.9)
1-3	19 (67.9)
4 or more	4 (14.3)
Maternal serum calcium level (mg/dL)	8.87±0.47
Gestational age (weeks)	39 (37-41)
Initial symptoms of admitted	
Labor pain	12 (42.9)
Premature rupture of membranes	11 (39.3)
Post-date pregnancy	3 (10.7)
Oligohydramnios	2 (7.1)
Induction of labor	
Yes	15 (53.6)
No	13 (46.4)
Induction agent	
Oxytocin	10 (66.7)
Dinoprostone	5 (33.3)
Type of delivery	
Vaginal delivery	28 (100)
Cesarean delivery	0 (0)
Time of delivery (hours)	6 (1-48)
Hour of birth	
Ante meridiem	16 (57.1)
Post meridiem	12 (42.9)
Episiotomy	
Yes	14 (50)
No	14 (50)

Values are presented as mean ± standard deviation, median (range), and n (%)

In the present study, we found that 10.7% of women who gave birth to infants with brachial plexus injury had a BMI of 30 kg/m^2 or more. The study conducted by Avram et al. (16) demonstrated that the rate of brachial plexus injury increased with maternal weight. We believe that increased maternal adiposity, both before and during pregnancy, contributes to disproportionate fetal growth and increases the risk of brachial plexus injury. In the present study, 57.1% of brachial plexus injuries occurred in women who had a prior vaginal delivery. In a study examining 78 infants, 58% of cases with brachial plexus injuries were multiparous. Multiparous women give birth to infants with higher birth weights than primiparous. Providers tend to underestimate birth weights in multiparous women and are less likely to perform necessary labor interventions. This approach contributes to an increased rate of brachial plexus injuries in women with a previous delivery (17). We identified GDM in 10.7% of cases involving brachial plexus injury.

A systematic review and meta-analysis encompassing approximately 30 million births reported that GDM significantly increased the risk of brachial plexus injury (odds ratio =5.33). Excessive and disproportionate fetal growth is more common in pregnancies complicated by GDM. Specifically, the ratio of fetal abdominal and head circumference tends to increase. Both excessive and disproportionate fetal growth contributes to the risk of plexus injury (9). We used induction to initiate labor in 53.6% of the women in our cohort. Similarly, Yenigül et al. (18) identified a 66.7% labor induction rate in cases of brachial plexus injury, demonstrating that labor induction significantly heightened the incidence of injury. We believe that initiating labor induction before adequate cervical ripening may contribute to the development of plexus injury by elevating *in utero* pressure. We also suspect that undetected cephalopelvic disproportion may impact the progress of injury. Therefore, a comprehensive evaluation should be conducted before initiating labor induction to identify potential risk factors that could increase neonatal morbidity. We used oxytocin as an induction agent in 10 women (66.7%) and dinoprostone in 5 women (33.3%). In the study by Louden et al. (19), the use of oxytocin was reported to increase the risk of brachial plexus injury by 2.5 times, and the risk increased by 3.7 times when tachysystole occurred with the use of oxytocin. In contrast, the use of prostaglandins was not associated with an increased risk. These findings suggest that oxytocin use, particularly when complicated by tachysystole, may further elevate the risk of fetal injury. Therefore, a thorough evaluation of the pelvis and cervix should be performed before initiating oxytocin, and careful adjustment of dosage and duration

Table 3. Evaluation of perinatal outcomes

	n=28
USG measurement of fetal FL (mm)	73.55±1.53
Percentiles for FL	
25th percentile	1 (3.6)
50th percentile	10 (35.7)
75th percentile	16 (57.1)
90-95th percentile	1 (3.6)
First minute APGAR	8 (5-9)
Fifth minute APGAR	9 (8-9)
Birth weight (grams)	
3000-3499	10 (35.7)
3500-3999	13 (46.4)
4000 or more	5 (17.9)
Newborn length (cm)	52.57±1.68
Newborn head circumference (cm)	35.11±1.28
Fetal gender	
Female	18 (64.3)
Male	10 (35.7)
Affected side of OBPI	
Right side	22 (78.6)
Left side	6 (21.4)
NICU admission	
Yes	2 (7.1)
No	26 (92.9)
Neonatal complication with OBPI	
None	17 (60.7)
Caput succedaneum	5 (17.9)
Subconjunctival hemorrhage	4 (14.3)
Clavicle Fracture	1 (3.6)
Hematoma in the adrenal area	1 (3.6)
Shoulder dystocia	
Yes	11 (39.3)
No	17 (60.7)

Values are presented as mean ± standard deviation, median (range), and n (%)
USG: Ultrasonography, FL: Femur length, APGAR: Activity pulse grimace appearance respiration, OBPI: Obstetric brachial plexus injury, NICU: Neonatal intensive care unit

during administration is essential. During the study period, a total of 9,930 cesarean deliveries were performed in our clinic, and no cases of brachial plexus injury were detected in the newborns. A study conducted with stratified analysis covering 22 years showed that cesarean section is a protective factor for the development of brachial plexus injury, with the greatest protective effect observed in cases of macrosomic fetuses (20). Cesarean delivery should be considered in the presence of high-risk factors for difficult delivery, such as macrosomia and malpresentation. Most births involving brachial plexus injury (57.1%) occurred during the ante meridian hours. Birth providers working during this time may experience increased sleep deprivation and fatigue, which could contribute to the higher incidence of plexus injury observed in the ante meridian.

Table 4. Clinical outcomes of fetuses with OBPI and their parents' caregiving scores

	n=28
Subgroups of palsy	
Erb paralysis	25 (89.3)
Klumpke paralysis	2 (7.1)
Total paralysis	1 (3.6)
Follow-up period (months)	12 (3-31)
Clinical follow-up results	
Transient injury	24 (85.7)
Permanent injury	4 (14.3)
Zarit scale of caregiver burden	
No to mild burden (0-21 score)	22 (78.6)
Mild to moderate burden (21-40 score)	6 (21.4)
Moderate to severe burden (41-60 score)	0
Severe burden (≥61 score)	0

Values are presented as median (range) and n (%)
OBPI: Obstetric brachial plexus injury

In the present study, 46.4% of fetuses with brachial plexus injury had a birth weight of 3500-3999 g, while 17.9% had a birth weight of 4000 g or more. Previous studies have identified fetal macrosomia as a strong risk factor for brachial plexus injury (9). In a study examining approximately 1 million birth records, a new warning range of 3500-3999 g was determined for the development of plexus injury, and it was reported that the damage increased by 7% for every 50 g increase in fetal weight (21). The important point is that obstetricians should remain vigilant for the possibility of brachial plexus injury when the fetal weight is between 3500 and 3999 g. This range should be carefully considered in the presence of additional risk factors, such as advanced maternal age, GDM, and malpresentation, and considered in labor management.

We found that 64.3% of newborns with brachial plexus injury were female. Previous research has demonstrated that female gender is a risk factor for OBPI (AOR: 1.38). However, some studies have indicated no significant relationship between fetal gender and plexus injury (22). We believe that fetal gender, in isolation, should not be considered a sole risk factor for plexus injury; rather, it should be assessed in conjunction with other coexisting risk factors. Furthermore, we believe that the ethnicity of the study populations may influence these findings. In our study, the right limb was affected in 78.6% of fetuses that developed brachial plexus injury. A recent review indicated that lesions on the right side were more common than on the left (23). Typically, the fetal head enters the pelvis in the left occiput transverse position and undergoes external rotation during the second stage of labor, with the right shoulder positioned near the mother's symphysis pubis. In such cases, downward lateral traction applied to the fetal head by the obstetrician may explain the development of lesions in the right limb.

Table 5. Comparison of maternal and obstetric characteristics between transient and permanent brachial plexus injuries

	Transient injury (n=24)	Permanent injury (n=4)	p
Maternal obesity			
Yes	3 (12.5)	0 (0)	0.497
No	21 (87.5)	4 (100)	
Multiparous			
Yes	15 (62.5)	1 (25)	0.196
No	9 (37.5)	3 (75)	
Induction of labor			
Yes	12 (50)	3 (75)	0.356
No	12 (50)	1 (25)	
Shoulder dystocia			
Yes	7 (29.2)	4 (100)	0.007
No	17 (70.8)	0 (0)	
Macrosomia			
Yes	3 (12.5)	0 (0)	0.497
No	21 (87.5)	4 (100)	
Values are presented n (%)			

In our cohort, clavicle fractures were observed in 3.6% of fetuses with OBPI. Previous research has reported that clavicle fractures are not a risk factor for developing plexus injury (24). However, other studies have indicated that the morphology of clavicular fractures is associated with plexus injury. Specifically, while there is no significant risk between fractures with transverse morphology and plexus injury, a significant correlation was reported between spiral and oblique morphology clavicle fractures and plexus injury (25). Moreover, some studies report that the likelihood of permanent neurological deficit is lower in cases where clavicular fractures accompany plexus injury, and the presence of a clavicular fracture may enhance recovery from palsy (26). We suggest that these differing results across studies are attributable to variations in the fracture mechanisms. For instance, fractures caused by excessive traction applied to the fetal head by the obstetrician may contribute more significantly to plexus injury. In contrast, intentional clavicular fractures during shoulder dystocia may result in less severe plexus injury. Shoulder dystocia occurred during labor in 39.3% of newborns with brachial plexus injury and all newborns with permanent damage developed shoulder dystocia at delivery (p=0.007). The incidence rates of shoulder dystocia and brachial plexus injury vary across different geographies, ranging from 47% to 78%. The presence of shoulder dystocia increases the risk of brachial plexus injury by approximately 100-fold (27). During shoulder dystocia, applying downward lateral traction on the fetal head to deliver the anterior shoulder can stretch and injure the brachial plexus.

Erb's palsy was detected in 89.3% of newborns who developed OBPI. It occurs due to damage to the upper trunk nerves involving C5, C6, and occasionally C7 (Erb's palsy plus). Approximately 85% of brachial plexus cases are classified as Erb's palsy (7). In our cohort, records showed no instances of Erb's palsy plus damage. We suspect that cases of Erb's palsy plus damage were documented as Erb's palsy. The median follow-up period for fetuses who developed brachial plexus injury in our study was 12 months. By the end of this period, 85.7% of cases showed recovery, while 14.3% resulted in permanent injury. According to the literature, the reported rate of permanent injury ranges from 12% to 50% (28). We believe that this wide range is associated with differences in developing healthcare systems across countries. When assessing the caregiving burden of parents of infants with brachial plexus injury, 78.6% reported "no to mild burden", while 21.4% reported a "mild to moderate burden". Given the prolonged recovery and rehabilitation process associated with plexus injuries, parents may face both psychological and financial challenges during this period (29). We hypothesize that the relatively low caregiving burden scores observed in our study were attributable to the free access to healthcare and social support services in our country.

Study limitations

The limitations of our study are its cross-sectional, retrospective and descriptive design. The strengths of our study include reporting the incidence of brachial plexus injury both annually and cumulatively over a six-year period, as well as presenting maternal, perinatal, and neonatal data of affected infants during this timeframe. Additionally, the follow-up of cases for a mean duration of 12 (3-31) months further strengthens our study.

Conclusion

The incidence of OBPI in this single tertiary center retrospective study was 1.01 per thousand births. In the presence of factors that lead to the development of plexus damage, such as shoulder dystocia, the obstetrician's experience is important. Cesarean section may serve as a protective factor against brachial plexus injury. The Erb's palsy subtype was more common, with the right limb being more frequently affected. Newborns with plexus injuries exhibited high recovery rates and, in our cohort, the reported parental caregiving burden was low.

Ethic

Ethics Committee Approval: *This study was approved by the Scientific Research Ethics Committee of University of Health Sciences Türkiye, Şehit Prof. Dr. İlhan Varank Training and Research Hospital (approval number: 2024/48, date: 20.02.2024).*

Informed Consent: *Informed consent was obtained from all participants.*

Footnotes

Author Contributions: *Surgical and Medical Practices: O.A., B.G., N.T., Concept: O.A., Design: O.A., B.G., N.T., Data Collection or Processing: O.A., Analysis or Interpretation: O.A., B.G., N.T., Literature Search: O.A., Writing: O.A.*

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