A retrospective analysis of risk factors for clavicle fractures in newborns with shoulder dystocia and brachial plexus injury: A single-center experience

Ali Erkan Yenigül¹, Nefise Nazlı Yenigül², Emre Başer³, Runa Özelçi⁴

¹Department of Orthopedics and Traumatology, Minister of Health Şanlıurfa Training and Research Hospital, Şanlıurfa, Turkey
²Department of Obstetrics and Gynecology, University of Health Sciences School of Medicine Şanlıurfa Mehmet Akif İnan Research and Training Hospital, Şanlıurfa, Turkey
³Department of Obstetrics and Gynecology, Bozok University, School of Medicine, Yozgat, Turkey
⁴Department of Obstetrics and Gynecology, University of Health Sciences School of Medicine Etilik Zübeyde Hanım Training and Research Hospital, Ankara, Turkey

ABSTRACT

Objective: We aimed to analyze the risk factors for clavicle fractures in newborns with shoulder dystocia and brachial plexus injury and to determine whether their incidence is associated with local characteristics.

Methods: This study was conducted as a retrospective trial between January 2017 and December 2018. Patients with clavicular fracture who were hospitalized in the neonatal intensive care unit of a community hospital were retrospectively analyzed. The clavicular fracture cohort was first divided into two groups and then two subgroups: patients with/without shoulder dystocia and patients with/without a brachial plexus injury. Peripartum and neonatal risk factors of these patients were reviewed using the patient information system. Any additional neurological or musculoskeletal trauma was noted. A multivariate logistic regression analysis was performed to determine independent predictors of shoulder dystocia and brachial plexus injury.

Results: A total of 46 patients with shoulder dystocia in 25 (54%) and brachial plexus injury in 12 (26%) were included in the study. The birth weight of patients with shoulder dystocia was 4,164 ± 412.7 g, and that of patients without was 3,535 ± 865.2 g (p=0.003). In 11 of 14 patients (44%) in whom labor was induced and whose infant had a fractured clavicle, the infant also had shoulder dystocia (p=0.029). Brachial plexus injury was found in 8 (66.7%) of 12 infants who were born by induced labor and who had a clavicular fracture (p=0.002). The regression analysis revealed that age and induction of labor were independent risk factors for brachial plexus injury (odds ratio=1.599 and 81.862, respectively). Gestational weight gain (p=0.003) and neonatal birth weight (p=0.047) were also found as independent risk factors for shoulder dystocia.

Conclusion: Evidence from this study has shown that not only birth age or birth weight but also excessive weight gain by mother and induction of labor may increase the risk of clavicular fracture with brachial plexus palsy. Advanced maternal age, multiparity, and deliveries after 39 weeks seem to be risk factors for a clavicular fracture with a brachial plexus injury.

Level of Evidence: Level IV, Therapeutic study

Introduction

The pathomechanics of the clavicle fracture, which is the bone most frequently fractured at birth, is unclear and unpredictable. The overall risk of clavicle fracture for all deliveries is 0.2-3.5% (1). The risk factors most frequently reported are instrumented delivery, macrosomia (2, 3), shoulder dystocia, postterm delivery, procedural induction of labor, prolonged labor, and newborn length ≥52 cm (3, 4).

Fractures of the clavicle may occur due to shoulder insertion or during uncomplicated deliveries. They can coexist with humeral fractures, traumatic brachial plexopathy, and injuries to the phrenic and recurrent laryngeal nerves (5). After shoulder dystocia, 25% of patients have a clavicular fracture, and 9% of newborns with a clavicular fracture also have brachial plexus injuries (6). More data are needed for better prediction and management of these complications by orthopedic surgeons. Therefore, we evaluated the risk factors for clavicular fractures in newborns born in a community hospital with shoulder dystocia and brachial plexus injury and determined whether their incidence was associated with local characteristics.

Materials and Methods

This study was conducted as a retrospective trial at the Şanlıurfa Training and Research and Hospital between January 2017 and December 2018. Patients with clavicular fracture who were hospitalized in the neonatal intensive care unit (NICU) of our hospital were analyzed. This study protocol was approved by the ethics committee (19/03/03). Informed consent was obtained from guardians of all participants.

The inclusion criteria were newborns who were diagnosed with a clavicular fracture and were radiographed for diagnostic confirmation. Patients whose medical information and radiographs could not be obtained, those whose fracture site was unclear, or in whom radiographs could not be taken correctly were excluded. Stillbirths were also excluded. A total of 46 patients with shoulder dystocia in 25 and brachial plexus injury in 12 were included. All newborns underwent a routine physical examination immediately after birth and before discharge from the inpatient clinic (24 h after delivery). The diagnosis of a clavicular fracture was confirmed by clinical findings (e.g., swelling, tenderness, and crepitus over the clavicle).
Radiographic confirmation was a required inclusion criterion in our study. The radiographs were interpreted by an experienced orthopedic surgeon. The clavicular fracture cohort was divided into two groups and two subgroups: patients with/without shoulder dystocia and patients with/without a brachial plexus injury. The brachial injury group encompassed patients with loss of the Moro reflex and persistent symptoms of Erb-Duchenne or Dejerine-Klumpke palsy after discharge from the hospital. During a vaginal delivery, if the obstetrician did not succeed in releasing the shoulder dystocia with simple traction, a corrective maneuver was applied. These maneuvers included the McRoberts maneuver, delivery of the posterior shoulder, the Wood screw maneuver, and the Rubin maneuver (7).

The following clinical data were reviewed using the patient information system: maternal age, parity, gestational weight gain (kg), gestational age at delivery (weeks), mode of delivery, fetal gender, neonatal birth weight (g), fetal head diameter (cm), fetal length (cm), meconium-stained amniotic fluid, induction of labor, fracture side, history of shoulder dystocia or intracranial hemorrhage, brachial plexus injury, reason for NICU admission, and length of hospital stay (days). Any additional neurological or musculoskeletal trauma was noted.

Gestational age was calculated using the first day of the last menstrual period and confirmed by the first trimester or early second trimester ultrasonography. Excessive weight gain by mother was defined as >13 kg (gained throughout the gestational period) [8]. Induction is the standard procedure for pregnant women hospitalized for delivery in our hospital. A vaginal ovule of dinoprostone was inserted into the posterior fornix in patients with a Bishop score ≤6. The duration of dinoprostone ovule administration was 12 h. Oxytocin (sympathin) infusion was started when the Bishop score reached 6-8. It was prepared as 5 units in 500 mL saline and was started with an initial dose of 4 μU/min, which was increased by 2 μU/min every 20 min. Prematurity was classified as an early preterm (delivery before 32 weeks) or late preterm (delivery at 32-36 weeks). Birth weight >4,000 g was defined as macrosomia. Gestational diabetes mellitus (GDM) was diagnosed by screening all patients with the 75 g oral glucose challenge test between gestational weeks 24 and 28. Diet and exercise were the first-line treatments. Patients were defined as GDM-A1 when their glucose level was controlled within the normal level using diet therapy, and GDM-A2 when insulin therapy was required to regulate their blood glucose level.

The level of the experience of the orthopedic surgeon was described as 3 [9].

Statistical analysis
Statistical analysis was performed using the Statistical Package for Social Sciences software version 20 (IBM SPSS Corp.; Armonk, NY, USA). Data are expressed as mean±standard deviation or as percentages. The distribution of the data was determined using visual (histograms and probability plots) and analytical methods (Kolmogorov-Smirnov and Shapiro-Wilk’s test). The Mann-Whitney U-test was used for the nonparametric numerical data, and Student’s t-test was adopted for the parametric numerical data. Categorical data were compared using the Chi-square or Fisher’s exact test. A multivariate logistic regression analysis was performed to determine independent predictors of shoulder dystocia and brachial plexus injury. A p value <0.05 was considered significant.

Results
In total, 59,622 live births occurred in our hospital during the study period. Orthopedic consultation was requested for 487 infants who were admitted to NICU. Of these, 46 were in accordance with the study criteria. Of those patients, 25 (54%) had shoulder dystocia, and 12 (26%) had a brachial plexus injury.

Risk factors for patients with and without shoulder dystocia in cases of a clavicular fracture are provided in Table 1. Gestational weight gain was 11.1±1.9 kg for patients without shoulder dystocya and 14.5±2.5 kg for shoulder dystocia (p<0.001). The birth weight of patients with shoulder dystocia was 4,164±2412.7 g, and that of patients without was 3,535±865.2 g (p=0.003). In 11 of 14 patients (44%) in whom labor was induced and whose infant had a fractured clavicle, the infant also had shoulder dystocia (p=0.029). No significant relationship was observed between delivery type and clavicular fracture. No shoulder dystocia occurred during the cesarean deliveries. No other risk factors were significantly different between the two groups.

| Table 1. Peripartum and neonatal risk factors of patients with shoulder dystocia and without shoulder dystocia in the case of clavicle fracture |
|---------------------------------------------------------------|
| No shoulder dystocia (n=21) | Shoulder dystocia (n=25) | P      |
|---------------------------------|--------------------------|--------|
| **Maternal age**                |                          |        |
| 28.5±6.3                        | 28.8±6.5                 | 0.757  |
| **Parity**                      |                          |        |
| 1.5±1.3                         | 3.6±1.4                  | 0.270  |
| **Gestational weight gain (kg)**|                          |        |
| 11.1±1.9                        | 14.5±2.5                 | <0.001 |
| **Gestational age at delivery (weeks)** |              |        |
| 37.5±3.4                        | 38.6±1.1                 | 0.117  |
| **Neonatal birthweight (g)**    |                          |        |
| 3,535±865.2                     | 4,164±2412.7             | 0.003  |
| **Fetal head (cm)**             |                          |        |
| 34.5±1.6                        | 34.8±1.3                 | 0.388  |
| **Fetal length (cm)**           |                          |        |
| 48.7±7.5                        | 50.8±0.9                 | 0.253  |
| **Meconium-stained amniotic fluid,** |                |        |
| n (%)                           |                          | 0.556  |
| No                              | 18 (90.0)                | 21 (84.0)|
| Yes                             | 2 (10.0)                 | 4 (16.0)|
| **Side of fracture. n (%)**     |                          |        |
| Right                           | 6 (28.6)                 | 13 (52.0)|
| Left                            | 15 (71.4)                | 12 (48.0)|
| **Gender. n (%)**               |                          |        |
| Female                          | 10 (47.6)                | 15 (60.0)|
| Male                            | 11 (52.4)                | 10 (40.0)|
| **Mode of delivery. n (%)**     |                          |        |
| Vaginal delivery                 | 18 (85.7)                | 25 (100.0)|
| Cesarean                       | 3 (14.3)                 | 0 (0.0) |
| **Induction of labor presence. n (%)** |                |        |
| No                              | 18 (85.7)                | 14 (56.0)|
| Yes                             | 3 (14.3)                 | 11 (44.0)|
| **Length of hospital stay (days)** | 9.3±19.2               | 6.1±8.2 | 0.892 |

C/S: Cesarean/VD: Vaginal delivery. Values are expressed as mean±SD or numbers and percent (%) p<0.05 is considered statistically significant.
Table 2. Peripartum and neonatal risk factors for patients with brachial plexus injury and without brachial plexus injury in the case of clavicle fracture.

| Risk Factor                        | No brachial plexus injury (n=34) | Brachial plexus injury (n=12) | p   |
|------------------------------------|----------------------------------|-------------------------------|-----|
| Maternal age (weeks)               | 38.8±1.1                        | 39.1±0.8                      | 0.38 |
| Parity                             | 1.2±0.3                         | 1.8±0.3                       | 0.22 |
| Gestational weight gain (kg)       | 12.5±2.8                        | 13.2±1.4                      | 0.21 |
| Gestational age at delivery (weeks)| 37.7±2.6                        | 39.1±3.3                      | 0.01 |
| Neonatal birthweight (g)           | 3,774.7±784.7                   | 4,186±368.3                   | 0.01 |
| Fetal head (cm)                    | 34.5±1.3                        | 35.1±1.5                      | 0.17 |
| Fetal length (cm)                  | 49.1±5.6                        | 51.1±1.1                      | 0.05 |
| Meconium-stained amniotic fluid, n (%) |                                |                               | 0.105 |
| No                                 | 30 (90.9)                       | 9 (75.0)                      |     |
| Yes                                | 3 (9.1)                         | 3 (25.0)                      |     |
| Right                              | 12 (35.3)                       | 7 (58.3)                      | 0.163 |
| Left                               | 22 (64.7)                       | 5 (41.7)                      |     |
| Gender, n (%)                      | 18 (52.9)                       | 7 (58.3)                      | 0.745 |
| Female                             | 16 (47.1)                       | 5 (41.7)                      |     |
| Mode of delivery, n (%)            | 31 (91.2)                       | 12 (100.0)                    |     |
| C/S rate                           | 3 (8.8)                         | 0 (0.0)                       |     |
| Induction of labor presence, n (%) | 28 (82.4)                       | 4 (33.3)                      | 0.002 |
| No                                 | 6 (17.6)                        | 8 (66.7)                      |     |
| Length of hospital stay (days), n (%) | 6.3±15.5                       | 10±9.9                        | 0.080 |

Table 3. Logistic regression analysis for risk factors associated with brachial plexus injury.

| Risk Factor                        | B     | SE    | p    | OR 95% CI    | Lower | Upper |
|------------------------------------|-------|-------|------|--------------|-------|-------|
| Maternal age (weeks)               | 0.470 | 0.193 | 0.015| 1.599        | 1.096 | 2.335 |
| Gestational age at delivery (weeks)| 0.456 | 0.641 | 0.477| 1.577        | 0.449 | 5.541 |
| Parity                             | -0.285| 0.550 | 0.604| 0.752        | 0.256 | 2.209 |
| Induction of labor                 | 4.405 | 1.859 | 0.018| 81.862       | 2.143 | 3127.655 |
| Gestational weight gain (kg)       | 0.159 | 0.193 | 0.409| 1.173        | 0.804 | 1.711 |

Table 4. Logistic regression analysis for risk factors associated with shoulder dystocia.

| Risk Factor                        | B     | SE    | p    | OR 95% CI    | Lower | Upper |
|------------------------------------|-------|-------|------|--------------|-------|-------|
| Neonatal birth weight (g)          | 0.003 | 0.001 | 0.047| 1.003        | 1.000 | 1.005 |
| Induction of labor                 | 1.268 | 1.477 | 0.391| 1.154        | 0.197 | 64.234 |
| Gestational age at delivery (weeks)| -0.062| 0.523 | 0.906| 0.940        | 0.337 | 2.622 |
| Gestational weight gain (kg)       | 0.513 | 0.174 | 0.003| 1.670        | 1.188 | 2.347 |

Discussion

Fetal birth weight is a risk factor for a clavicular fracture with shoulder dystocia; advanced maternal age, multiparity, and deliveries after 39 weeks are risk factors for a clavicular fracture with a brachial plexus injury. Excessive weight gain by mother and induction of labor increase the likelihood of clavicular fractures with both complications.

The incidence of clavicular fracture in our hospital was 0.77 per 1,000 live births, that of brachial plexus injury with a clavicular fracture was 0.20 per 1,000 live births, and the incidence of shoulder insertion with a clavicular fracture was 0.41 per 1,000 live births.

The clavicle absorbs trauma to the shoulder joint. Therefore, it is expected that the clavicle would be affected in cases of shoulder trauma. The diagnosis of an asymptomatic clavicular fracture is made...
by examination after suspicion in most centers, and routine radiography is not required. In our study, the low incidence of a clavicular fracture (0.07%) can be attributed to our inclusion of only patients who asked for an orthopedic consultation and the experience of the team managing deliveries in our center. In addition, increased cesarean rates in Turkey may have decreased the number of such cases (10). About 26% of patients with a clavicular fracture also sustained a brachial plexus injury. This incidence is consistent with other data in Turkey (11). However, clavicular fractures are associated with shoulder dystocia in almost 50% of patients. Due to the retrospective design of our study, some clavicular fractures without shoulder dystocia may have been missed.

A substantial portion of prenatal care is focused on trying to prevent fetal macrosomia by minimizing abnormal maternal weight gain and managing gestational diabetes (8). According to the Institution of Medicine recommendations, excessive weight gain during pregnancy for overweight women is defined as a gestational weight gain >13 kg (12). In recent studies, it has been shown that excessive weight gain could cause complications other than GDM. Louden et al. found that excessive weight gain was observed in 71% of brachial plexus birth injury compared with 52% of controls (8). Similarly, in our study, excessive weight gain was all accompanied by brachial plexus injury or shoulder dystocia with clavicle fracture. In order to be a clinically useful predictor of clavicle fracture with complications, the risk must be accurately ascertained and assessed at a time when an intervention is still feasible. Perhaps serious obstetric complications can be prevented by stimulation of patients and strict follow-up during pregnancy.

Fetal birth weight is reportedly an important factor in newborn clavicular fractures. For example, Özden et al. showed that birth weight >4,000 g was an independent risk factor for clavicular fracture (13). In our study, clavicular fractures were associated with shoulder dystocia in patients with an average fetal weight >4,000 g. Unlike previous studies, although the average fetal weight was >4,000 g in patients with clavicular fracture and a brachial plexus injury, the risk was not statistically significant. In addition, Karahanoglu et al. reported that the actual risk factor for a clavicular fracture and brachial plexus injury was birth weight, not fetal weight (11). To increase the likelihood of predicting a brachial plexus injury at this stage, it may be advisable to confirm birth weight by specialized ultrasonography.

An association has been reported between labor characteristics, brachial plexus injury, and birth trauma (14, 15). Among the risk factors we analyzed, advanced maternal age, multiparity, delivery after 39 weeks, and induction of labor increased the risk for a clavicular fracture in cases of brachial plexus injury. We found that induction of labor (11), which has been shown to increase the risks for a clavicular fracture and shoulder dystocia, also increased the association between shoulder dystocia and brachial plexus paralysis. In a similar study (11), augmentation did not increase the risk, but induction of labor increased the complications associated with clavicular fracture; this association was attributed to a pelvis not suitable for a normal delivery.

Although some studies have shown that nulliparity is a risk factor for clavicular fracture (16, 17), parity was not a clear risk factor in our study. Multiparity was a risk factor in cases of clavicular fracture with a brachial plexus injury, possibly due to the population reporting high parity. Although it is reasonable that the association between these complications would increase with an increase in the baby’s weight in the later weeks of pregnancy, the reason for the risk posed by advanced maternal age could not be attributed to a specific reason (11, 18). In addition, some studies have emphasized that brachial plexus injuries associated with clavicular fractures may be transient (6). As our study produced no data relevant to this question, such as brachial plexus injury without fracture, we could not draw a conclusion about these cases.

A decrease in fetal injury with an increasing incidence of cesarean section has been suggested in studies by Lurie et al. and Puza et al. (4, 19). Cesarean birth may be employed to guarantee that these complications will not occur in orthopedics and gynecology departments where medico-legal problems are experienced. However, Alexander et al. found that 1.1% of cesarean deliveries involved fetal injury. Clavicular fractures occurred in 0.03% of all cesarean sections (20). In addition, Choi et al. found that the incidence of clavicular fractures in cesarean deliveries was similar to that reported in the literature (18). In our study, we found no significant relationship between delivery type and clavicular fracture with shoulder dystocia or brachial plexus injury. Although three patients who underwent cesarean had none of the accompanying complications, one clavicular fracture occurred. For fractures whose etiology is unclear, cesarean is not always guaranteed to prevent these complications. A vaginal delivery may not increase the risk of brachial plexus injury accompanying a primary clavicular fracture, but it has been shown to be a risk factor for increasing the neonatal brachial plexus palsy persistence in patients with a brachial plexus injury (21). The greater prevalence of left occult anterior deliveries, which cause more pressure on the right shoulder, increases the incidence of right clavicular fractures during vaginal delivery (20), but our study did not find a significant relationship between birth position and complications accompanying a fracture. Furthermore, the coexistence of clavicular fractures and shoulder dystocia or brachial plexus injury is higher in the right fractures. Increased pressure on the right clavicle due to left occiput anterior deliveries may increase the association of complications with the clavicle fracture or it might be accidental. Fracture side analyzed according to the mode of delivery may also illuminate this situation.

Unlike other studies, we included a logistic regression analysis for risk factors associated with brachial plexus injury and shoulder dystocia. We found that maternal age and induction of labor were independent risk factors for clavicular fractures in patients with a brachial plexus injury. Age increased this risk by 1.5 times, and induction increased it by 87 times. This significant effect of induction was attributed to the fact that we could not reach some of the patients with isolated clavicular fractures. Indeed, our finding about the induction of labor by the the American College of Obstetricians and Gynaecologists (ACOG) included a combination of endogenous and exogenous factors that are linked with brachial plexus injury (22). Therefore, we should reevaluate patients before induction begins and consider the risks along with the potential benefits. In addition, although induction of labor increases the persistence of brachial plexus palsy, advanced maternal age was not considered a risk factor for it (21). Neonatal birth weight is an independent risk factor for clavicular fracture with shoulder dystocia. Cesarean birth may be a good alternative to prevent these complications in patients with birth weight >4,000 g.

Among the strengths of this study were that we discussed rare fractures and complications. Many studies have conducted risk analyses of clavicular fractures, shoulder dystocia, or brachial plexus injury, but we found no previous studies that questioned the associations of
clavicular fractures with shoulder dystocia and brachial plexus injury. Our regression analysis showed that the risk of clavicle fractures increases with brachial plexus injury and shoulder dystocia.

Our study has some limitations. First, it was retrospective in design. Therefore, the determination of perinatal risk factors was limited. Some studies have reported that GDM increases the risk of brachial plexus injuries and clavicular fractures (11, 23) or is associated with an increased risk of neonatal injury after shoulder dystocia (14). We could not include all risk factors due to insufficient medical record data of the newborns and their mothers. Second, because our hospital has the highest number of births in the country, it is difficult to find some records, and some patients are difficult to reach and therefore could not be included in the study. Third, the exclusion of patients without radiographs for the diagnosis of clavicular fracture reduced the number of patients in this study. Fourth, brachial plexus injury was not followed up in all patients whom we diagnosed, so no 1-year follow-up information was available.

In conclusion, we assessed the importance of all potential risk factors for clavicular fractures, shoulder dystocia, and brachial plexus injury. Not only birth age or birth weight but also excessive weight gain by the mother and induction of labor increased the risk of clavicular fracture with brachial plexus palsy. Fetal birth weight, advanced maternal age, multiparity, and deliveries after 39 weeks increase the coexistence of these conditions vary and cause serious medico-legal problems. In particular, older pregnant women should be evaluated once more before induction, and a cost-benefit calculation should be made. In addition, although caesarian birth is not a definitive option once more before induction, and a cost-benefit calculation should be made. In addition, although caesarian birth is not a definitive option, it may be a good alternative for preventing fracture and nerve damage, it may be a good alternative for infants weighing >4,000 g. A prospective observational study with more patients is needed to identify the detailed risk factors.

Ethics Committee Approval: Ethics committee approval was received for this study from the Ethics Committee of Harran University (19/03/03).

Informed Consent: Informed consent was obtained from guardians of all participants.

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