Atlanto Axial Dislocation Early Experience of 30 Cases with Aberrant Vertebral Artery

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ABSTRACT:

Background: *Atlantoaxial dislocation (AAD) refers to the instability occurring between C1 and C2, which may lead to spinal cord compression and neurological impairments. Contemporary C1–C2 fixation provides favorable results; however, variations in the vertebral artery elevate surgical risks. This research assesses the clinical characteristics, imaging results, surgical approaches, and initial outcomes of AAD associated with vertebral artery anomalies in Bangladesh.* ***Methods:*** *This retrospective research at Dhaka Medical College Hospital encompassed 30 patients with atlantoaxial dislocation and vertebral artery abnormalities who underwent surgical treatment in 2024. Assessment relied on clinical observations, Nurick classification, and imaging techniques (X-ray, CT, MRI, CTA/MRA). Patients received personalized C1–C2 or occipitocervical fixation while ensuring the safety of the vertebral artery. Outcomes evaluated encompassed reduction, fusion, neurological enhancement, and complications, analyzed via SPSS-26 with ethical consent.* ***Results:*** *A total of 30 patients with atlantoaxial dislocation and vertebral artery abnormalities received surgical treatment, primarily young males with congenital causes. The majority experienced neck pain (93.3%) and myelopathy (80%), with 80% exhibiting cord compression and a high-riding vertebral artery being the most frequent abnormality. C1–C2 fixation resulted in a 90% reduction (n=27) and a 93.3% fusion rate (n=28), with a 3.3% incidence of vertebral artery injury (n=1). In total, 80% experienced no complications, showing considerable neurological enhancement after surgery.* ***Conclusion:*** *C1–C2 fixation in atlantoaxial dislocation accompanied by vertebral artery anomalies is both safe and effective, resulting in high fusion rates and favorable neurological results. Thorough preoperative vascular evaluation is crucial to reduce complications.*

Keywords: Atlanto Axial Dislocation, Aberrant Vertebral Artery, Radiological Findings, Surgical Outcomes.

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INTRODUCTION:

Atlantoaxial dislocation (AAD) refers to instability or misalignment between the atlas (C1) and axis (C2), which can lead to possible spinal cord compression and neurological impairments. It stems from congenital, traumatic, inflammatory, or degenerative origins and poses surgical difficulties because of the intricate craniovertebral structure [1,2]. The atlantoaxial joint accounts for approximately 50% of cervical rotation and relies on robust bony and ligamentous support for its stability. Disruption may lead to instability, neck pain, myelopathy, cranial nerve impairments, gait issues, and respiratory problems, which makes early diagnosis and surgical stabilization crucial to avoid lasting neurological harm [3,4]. The management of AAD has shifted from the use of wiring and transarticular screws to segmental fixation of C1–C2. The Goel–Harms method is currently favored for stable fixation, correction of deformities, and elevated fusion rates; however, it necessitates meticulous awareness of vertebral artery anatomy [5,6]. The vertebral artery takes a variable path at the craniovertebral junction, rising from C2 to C1 and subsequently to the foramen magnum. Variations, including high-riding or abnormal arteries, are more frequent in CVJ anomalies and limit safe corridors for screw placement, raising the risk of vascular damage during surgery [7,8]. Injury to the vertebral artery is a severe complication of C1–C2 fixation, which may lead to hemorrhage, stroke, neurological deficits, or fatality. Its prevalence varies between 0–8% and is greater with anatomical differences; thorough preoperative evaluation is crucial despite advanced imaging techniques [9,10].

A study on atlantoaxial dislocation associated with high-riding vertebral artery addressed using C2

translaminar screws indicated that this method provides a secure fixation option by preventing vertebral artery damage while obtaining stable fusion and positive clinical and radiological results [11]. An investigation into congenital atlantoaxial dislocation, whether accompanied by occipitalized atlas or not, suggested a risk stratification framework for vertebral artery susceptibility during surgery, assisting surgeons in predicting anatomical differences and minimizing the chances of vertebral artery damage during craniovertebral junction stabilization operations [12].

Research conducted in Bangladesh with 30 cases of atlantoaxial dislocation treated by posterior decompression and C1 lateral mass–C2 pedicle screw fixation demonstrated successful neural decompression, stable fixation, elevated fusion rates, and significant clinical improvement alongside low complication rates. A different case report from Bangladesh discussed an unusual terminal vertebral artery in atlantoaxial dislocation, underscoring the necessity of thorough preoperative vascular imaging to avoid vertebral artery damage during craniovertebral junction surgery [13,14].

In Bangladesh, there is scarce information on atlantoaxial dislocation with an abnormal vertebral artery, particularly concerning the surgical safety and results of C1–C2 fixation. This research intends to evaluate the clinical characteristics, imaging results, surgical results, and treatment safety in individuals with atlantoaxial dislocation linked to unusual vertebral artery anomalies.

MATERIALS AND METHODS

Study Design and Setting

This retrospective observational case series was conducted at the Department of Neurosurgery, Dhaka Medical College Hospital (DMCH) and Green life Medical College Hospital, Dhaka, Bangladesh. The study evaluated the early surgical experience in managing patients with atlantoaxial dislocation (AAD) associated with aberrant vertebral artery anatomy.

Study Period

Patients who underwent surgical treatment between January 2024 and December 2024 were included in the study. Data collection and analysis were performed retrospectively from hospital records, operative notes, radiological databases, and follow-up documentation.

Study Population

A total of 30 consecutive patients diagnosed with atlantoaxial dislocation and associated vertebral artery anomalies who underwent surgical stabilization during the study period were included.

Inclusion Criteria

- Patients diagnosed with atlantoaxial dislocation based on clinical and radiological findings.
- Presence of vertebral artery anomaly identified on preoperative vascular imaging.
- Patients who underwent surgical intervention at Dhaka Medical College Hospital during the study period.
- Availability of complete clinical, radiological, operative, and follow-up data.

Exclusion Criteria

- Patients without demonstrable vertebral artery anomalies.
- Patients managed conservatively without surgery.
- Patients with incomplete medical records or inadequate follow-up data.
- Revision surgeries performed for procedures done at other institutions.

Preoperative Evaluation

All patients underwent detailed clinical assessment including neurological examination. Demographic characteristics, presenting symptoms, etiology of AAD, and neurological status were recorded. Neurological function was assessed using the Nurick grading system.

Radiological evaluation included dynamic cervical spine radiographs, computed tomography (CT) scan with craniovertebral junction reconstruction, magnetic resonance imaging (MRI), and CT angiography (CTA) or magnetic resonance angiography (MRA) to delineate vertebral artery anatomy. The reducibility of atlantoaxial dislocation, presence of basilar invagination, spinal cord compression, T2-weighted cord signal changes, and vertebral artery anomalies were documented.

Surgical Technique

The choice of surgical procedure was individualized according to the patient's anatomical characteristics, reducibility of the dislocation, and vertebral artery course. Surgical stabilization techniques included C1 lateral mass–C2 pedicle screw fixation, C1 lateral mass–C2 laminar screw fixation, occipitocervical fixation, and transarticular screw fixation. Particular attention was paid to preoperative vascular imaging findings to minimize the risk of vertebral artery injury.

Data Collection

Data were collected retrospectively from patients' medical records, operative notes, radiological databases, and follow-up documents using a structured data collection form. Information regarding demographic characteristics, including age and sex, clinical presentation, etiology of atlantoaxial dislocation, and preoperative neurological status was recorded. Radiological data were obtained from

cervical spine radiographs, computed tomography (CT), magnetic resonance imaging (MRI), and CT angiography (CTA) or magnetic resonance angiography (MRA), focusing on the reducibility of atlantoaxial dislocation, presence of basilar invagination, spinal cord compression, T2-weighted cord signal changes, and vertebral artery anomalies. Operative details including the type of fixation technique employed, operative duration, intraoperative blood loss, and vascular complications were documented. Postoperative outcome measures, including adequacy of reduction, fusion status, neurological improvement according to the Nurick grading system, and procedure-related complications, were collected from follow-up records and radiological assessments.

Follow-up and Outcome Assessment

Patients were followed clinically and radiologically after surgery. Neurological status was reassessed using the Nurick grading system at follow-up visits. Fusion was assessed using follow-up radiographs and/or CT scans. Surgical outcomes included adequacy of reduction, fusion rate, neurological improvement, and procedure-related complications.

Statistical Analysis

Data were analyzed using Statistical Package for the Social Sciences (SPSS) version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD), whereas categorical variables were presented as frequencies and percentages. Preoperative and postoperative neurological outcomes were compared descriptively using Nurick grade distributions. Results were presented in tables and figures as appropriate.

Ethical Considerations

The study was conducted in accordance with the principles of the Declaration of Helsinki. Approval was obtained from the Institutional Review Board/Ethical Review Committee of Dhaka Medical College. Patient confidentiality was maintained throughout the study, and all collected data were anonymized prior to analysis.

RESULTS

A total of 30 patients with atlantoaxial dislocation (AAD) associated with aberrant vertebral artery anomalies underwent surgical management during the study period. The demographic profile, clinical presentation, radiological findings, surgical characteristics, and outcomes are summarized below.

Table 1 shows the majority of patients were aged between 21 and 40 years (50.0%), with a male predominance (60.0%). Congenital pathology was the most common etiology (53.3%), followed by degenerative (23.3%) and traumatic causes (16.7%). Neck pain was the most frequent presenting symptom (93.3%), while myelopathy was observed in 80.0% of patients. Limb weakness and gait disturbance were present in 66.7% and 60.0% of cases, respectively.

Table 1. Baseline Demographic and Clinical Characteristics of Patients (n=30)

Variables	Frequency (n)	Percentage (%)
Age group (years)		
≤20	6	20.0
21–40	15	50.0
>40	9	30.0
Sex		
Male	18	60.0
Female	12	40.0
Etiology		
Congenital	16	53.3
Degenerative	7	23.3
Traumatic	5	16.7
Rheumatoid arthritis	2	6.7
Clinical presentation		
Neck pain	28	93.3
Myelopathy	24	80.0
Limb weakness	20	66.7
Gait disturbance	18	60.0
Sensory deficit	15	50.0
Occipital headache	12	40.0

Table 2 shows radiological evaluation revealed reducible AAD in 60.0% of patients, whereas 40.0% had irreducible dislocation. Basilar invagination was identified in 33.3% of cases. Cervical cord compression was present in 80.0% of patients and T2-weighted cord signal changes were observed in 46.7%. High-riding vertebral artery represented the most common vascular anomaly, being identified unilaterally in 46.7% and bilaterally in 26.7% of patients.

Table 2. Radiological Findings and Vertebral Artery Anomalies (n=30)

Variables	Frequency (n)	Percentage (%)
Reducible AAD	18	60.0
Irreducible AAD	12	40.0
Basilar invagination	10	33.3
Cord compression on MRI	24	80.0
T2 cord signal changes	14	46.7
Vertebral artery anomaly		

Unilateral high-riding vertebral artery	14	46.7
Bilateral high-riding vertebral artery	8	26.7
Persistent first intersegmental artery	5	16.7
Vertebral artery fenestration	2	6.7
Vertebral artery loop anomaly	1	3.3

Table 3 presents the most commonly performed procedure was C1 lateral mass–C2 pedicle screw fixation (46.7%), followed by C1 lateral mass–C2 laminar screw fixation (26.7%). The mean operative duration was 212.5±42.3 minutes and mean intraoperative blood loss was 345.8±118.7 mL. Successful reduction was achieved in 90.0% of patients, while radiological fusion was documented in 93.3%. Vertebral artery injury occurred in one patient (3.3%).

Table 3. Operative Characteristics and Surgical Outcomes (n=30)

Variables	Value
Surgical procedure	n (%)
C1 lateral mass–C2 pedicle screw fixation	14 (46.7)
C1 lateral mass–C2 laminar screw fixation	8 (26.7)
Occipitocervical fixation	6 (20.0)
Transarticular screw fixation	2 (6.6)
Operative parameters	
Operative time (minutes), Mean ± SD	212.5 ± 42.3
Blood loss (mL), Mean ± SD	345.8 ± 118.7
Outcome measures	
Adequate reduction achieved	27 (90.0)
Fusion achieved	28 (93.3)
Vertebral artery injury	1 (3.3)

Table 4 shows postoperative complications were infrequent; superficial wound infection was the most common complication (6.7%), followed by cerebrospinal fluid leak and screw malposition (3.3% each). Overall, 80.0% of patients had an uneventful postoperative course.

Table 4. Neurological Outcome and Postoperative Complications (n=30)

Postoperative complications	Frequency (n)	Percentage (%)
Superficial wound infection	2	6.7
Cerebrospinal fluid leak	1	3.3
Screw malposition	1	3.3
Neurological deterioration	1	3.3
No complication	24	80.0

Figure I show comparison of preoperative and postoperative Nurick grades demonstrated a favorable neurological outcome following surgery. The proportion of patients with lower Nurick grades (0–1) increased substantially after intervention, whereas the number of patients with higher grades (3–5) decreased, indicating improvement in functional status.

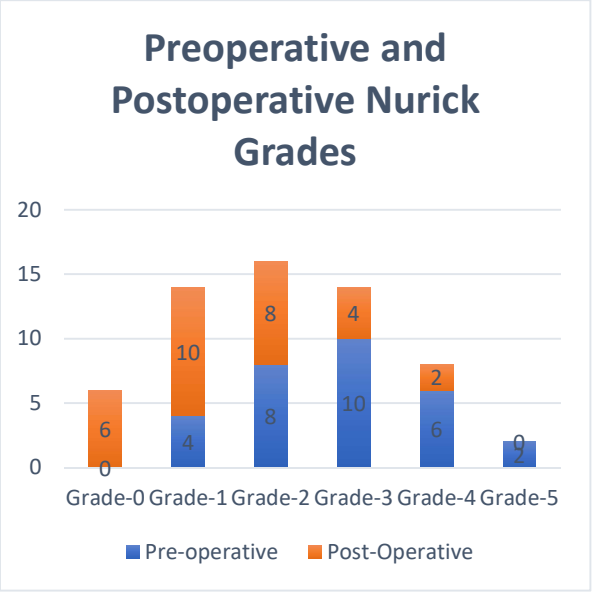

Figure I. Distribution of preoperative and postoperative Nurick grades among patients with atlantoaxial dislocation and aberrant vertebral artery anomalies (n=30).

In this series of 30 patients with atlantoaxial dislocation and aberrant vertebral artery anomalies, congenital pathology was the predominant etiology and neck pain with myelopathy constituted the most frequent clinical presentation. High-riding vertebral artery was the commonest vascular anomaly encountered. Surgical stabilization achieved a high rate of successful reduction (90.0%) and fusion (93.3%), with neurological improvement observed in 80.0% of patients. The incidence of vertebral artery injury and other major complications was low, suggesting that careful preoperative vascular assessment and individualized fixation strategies can facilitate safe and effective management of these complex craniovertebral junction abnormalities.

DISCUSSION:

The current study revealed that the majority of patients with atlantoaxial dislocation were young males with

congenital causes, typically showing neck pain, myelopathy, limb weakness, and gait abnormalities. A significant clinical series of atlantoaxial instability indicated that congenital factors are the predominant cause, and that typical presenting characteristics include progressive myelopathy and motor deficits, reinforcing the results of the current study and highlighting the necessity for early diagnosis and intervention [15].

This study discovered that the majority of patients had reducible AAD, with basilar invagination in 33.3%, cord compression in 80%, and T2 signal alterations in 46.7%, while the high-riding vertebral artery was the most prevalent vascular anomaly. These results align with evidence indicating a significant link between atlantoaxial instability and anomalies of the vertebral artery/axis, highlighting the importance of detailed CT and CT angiography for detecting bony and vascular variations and facilitating safe surgical planning [16,17].

Our study indicated that fixation using C1 lateral mass and C2 pedicle screws was the most frequently employed method, achieving high rates of reduction and fusion, while maintaining a low incidence of vertebral artery injury and reasonable operative duration and blood loss.

These results align with extensive clinical studies indicating that posterior C1–C2 fixation offers a safe, stable, and effective solution for atlantoaxial instability, demonstrating high fusion rates and minimal complications [18].

The current study demonstrated a low rate of complications, with superficial wound infections being the most frequent, while CSF leaks, screw malposition, and neurological deterioration each occurred in 3.3%; 80% of patients experienced no complications. These results align with extensive studies indicating minimal overall morbidity following atlantoaxial fusion when proper techniques and meticulous surgical planning are implemented, affirming the safety of posterior fixation methods [19].

The current research demonstrated notable neurological enhancements after surgery, evidenced by a rise in patients with lower Nurick grades (0–1) and a decline in those with higher grades (3–5), as well as a 90% reduction, 93.3% fusion rates, and 80% neurological improvement. These results align with research indicating that surgical adjustment and stabilization for atlantoaxial dislocation and craniovertebral junction disorders result in significant neurological improvement, enhanced functional results, and elevated fusion rates [6,20].

In summary, this study finds that posterior C1–C2 fixation for atlantoaxial dislocation with vertebral artery abnormalities is safe and effective, offering high fusion rates, notable neurological enhancement, and low complication rates when careful preoperative planning is conducted.

CONCLUSION:

C1–C2 fixation for atlantoaxial dislocation linked with unusual vertebral artery anomalies is a reliable and effective surgical choice, yielding high reduction rates, strong fusion, and considerable neurological enhancement while exhibiting a low rate of major complications and vertebral artery damage. Thorough preoperative assessment of vertebral artery structure, detailed surgical planning, and choosing proper fixation methods are vital to reduce intraoperative dangers and attain the best clinical and functional results.

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