

Reviewer A

Some very important aspects were not addressed by the authors or at least not clear to me.

Reply: Upon addressing the reviewer's comments, we believe these unclear aspects are a consequence of the limitations inherent to the NIS database, causing a lack of clarity. Reports of imaging, detailed neurologic findings, patient follow-up beyond hospitalization, and clinical exams/lab values are absent from the NIS database. We have included additional commentary in our limitations section of the manuscript to further elucidate and help make these aspects clear. Thank you for bringing these unclear concepts to our attention.

Changes in the text: Page 12 Discussion, Lines 5-6

1) How was AARD evaluated be decision making of the treatment, Dvorak CT?

Reply: A limitation that exists with the use of the NIS database is that it does not offer clinical decision making for a diagnostic modality. In the NIS, the diagnoses and procedures in our study population are only identified through the use of ICD10 codes, and thus, we are unfortunately unable to trace clinical data that determines each diagnosis. In practice, most cases of AARS are diagnosed by CT, as mentioned in our introduction (1).

2) Please explain the decision process for treatment based on the amount of dislocation and mobility and osseous status of the C1/2 joint

Reply: Within the NIS database, there do not exist descriptions of the severity of dislocations, mobility, and osseous status of the C1/2 joint. Imaging reports are also not provided in this nationwide database. Additional commentary has been added to the limitation section of the paper to further describe this.

Changes in the text: Page 12 Discussion, Lines 5-6

3) Please compare the groups based on the aforementioned aspects and present data for the clinical outcome regarding pain and limitation in daily life at 6 and 12 month after initial presentation.

Reply: As the NIS database is a query of national discharge data, it is limited to a patient's hospitalization stay, and does not allow tracking of clinical outcomes for long term follow-up.

4) in case on none surgical treatment please prsent the treatment path for these patients-orthosis or not?

Reply: As advised, we queried our AARS patient-selected database for the treatments given to patients with non-surgical management. In practice, the treatment modality for non-surgical management would likely be cervical orthosis. However, in our query, using the diagnostic/procedural codes Z4689, F0DZ7EZ for orthosis, we found no corresponding results in our patient sample. Thus, these codes for non-surgical treatment management with cervical orthosis are likely unreliable and remain a limitation for this study. An additional note has been added to the limitation section pertaining to this.

Changes in the text: Page 12 Discussion, Lines 1-2

Reviewer B

Abstract:

Overall the abstract is well written.

Introduction:

Line 66: do not need to say “in adults”

Reply: Removed the term “in adults”

Changes in the text: Page 4 Introduction, Line 12

Line 68: predominance in females over males.... however in discussion you note the literature shows a predominance in men?

Reply: Thank you for identifying this discrepancy. We have acknowledged the female predominance of AARS in the discussion and elaborated further to explain that our sample size, along with the overall predominance of males in trauma as a whole may contribute to our study findings.

Changes in the text: Page 11 Discussion, Lines 10-12

Line 76: “Closed reduction and immobilization...” please cite source

Reply: Citation added for this information.

Changes in the text: Page 4 Introduction, Line 22

Line 104: “to evaluate characteristics of presenting with AARS, the presence....”

Reply: The objective sentence in the Introduction has been more concisely reworded. Thank you for the suggestion.

Changes in the text: Page 5 Introduction Line 8

Methods:

Can the authors elaborate more on the NIS database? Whats the end point of data collection? Is it just hospital stay or overall 30 day complication rate

Reply: Paragraph added in the Methods section to elaborate more on the data acquired from the NIS and to describe that the endpoint is the hospital stay only.

Changes in the text: Page 5 Methods, Lines 12-19

How does this database compare to others such as nsqip?

Reply: Commentary on the differences and advantages of the NIS compared to the NSQIP has been added in the introduction.

Changes in the text: Page 5 Introduction, Lines 2-6

Please better define how you categorized severity of injury? Could you do an analysis of which CPT code categories were associated with death or non op treatment?

Reply: While the NIS database allows for the query of ICD10 codes, analysis using CPT is currently unavailable in the database. In this study, the severity of injury is defined using diagnosis related groups (DRG), which is coded as a three-tiered system for injuries as follows: 1) without comorbidity or complication, 2) with comorbidity or complication, 3) with major comorbidity and complication. From these DRG codes, patients with DRGs in the second and third categories (with or with major comorbidity and complication) were defined to have extensive trauma. Additional commentary has been added to the Methods to further elucidate this. Thank you for this suggestion.

Changes in the text: Page 6 Methods, Lines 21-24

Discussion:

Study is also limited by inability to classify C1-2 rotatory instability, if a fracture is present, was a closed reduction trialed?

Reply: As advised, we performed a new analysis of our study population to determine any associations between cervical fracture and cervical fusion within the cervical vertebrae. In this analysis, we found no significant association between cervical fracture of the C1-C7 vertebrae and cervical fusion ($p = 0.074$), using the following ICD10 codes: S120, S121, S122, S123, S124, S125, S126, S128, S129.

Also, those that were discharged, it is unknown if they later went on to fusion

Reply: This is correct and is noted as a limitation of the NIS in our study.

How do your results compare to those from,

Hendow CJ, Beschloss A, Cazzulino A, et al. Change in rates of primary atlantoaxial spinal fusion surgeries in the United States (1993-2015). J Neurosurg Spine. Jan 24 2020:1-7. doi:10.3171/2019.11.SPINE19551

Reply: As suggested, we thoroughly reviewed Hendow et al. and have added additional commentary in the Discussion comparing our rates of mortality.

Changes in the text: Page 9 Discussion, Lines 20-24

Tables & Figures:

Tables are fine

References: Acceptable

Overall: The authors performed an interesting study however I think it overall fails to answer its question of outcomes given that it is unknown if patients with rotatory subluxation later required fusion or underwent closed reduction?

Reply: Thank you for your detailed suggestions and comments. Due to the inherent functionality of the NIS, we had limited ability to evaluate post-discharge clinical outcomes. However, within these limitations we believe our study provides valuable knowledge on the treatment of AARS in the hospital setting. We show that primary fusion of patients is associated with favorable outcomes as evaluated by the variables available in the NIS dataset (mortality, complications, etc.). The study population selected for in this analysis had a primary diagnosis code of S13.120, accounting for initial encounter, subsequent encounter, as well as sequela. Subsequent encounters are defined as hospital encounters after a patient has already received active treatment of the injury from a previous stay and is receiving routine care for the injury during the healing or recovery phase. To further elucidate these results, we had performed an analysis selecting for a primary ICD10 code of S13.120D OR S13.120S, which selects specifically for subsequent encounters rather than initial encounters (S13.120A). From this subset, we found only 40 patients were characterized as subsequent encounters following initial injury, and of these patients, only 5 received fusion (OR = 0.369, CI 95% 0.143-0.953, p = 0.044). Although this cohort of patients with subsequent encounters had significantly less cervical fusion procedures, it was a much smaller sample of only 40 patients and thus, we had opted not to include this into our study.

Given the sparsity of data in the literature regarding this injury I believe that this study adds value. I think with more discussion in how the severity of injury (specific grading) correlated with complication and treatment choice with strengthen the results/discussion.

Reply: We have inserted additional commentary in the Discussion that further details how the severity of injury may be related to the withholding of aggressive treatment in our study population.

Changes in the text: Page 10 Discussion, Lines 6-7

Reviewer C

This is a seemingly straightforward database query for patients with C1-2 subluxation using ICD-10 codes, including disease and procedure. The authors are very transparent in providing exactly which search terms were employed. They used the single ICD-10 code S13.120 for "atlantoaxial rotary subluxation." There are of course several mechanisms that could lead to such a coding, including infectious, inflammatory, traumatic, and so on. It seems that the authors are keen to deal specifically with those presenting with acute trauma, hence their supplemental tables 3 and 4, among other things. **Can the authors more clearly state therefore how many patients had acute trauma versus those presenting with other etiologies (i.e. infectious process) responsible for the AA subluxation?**

Reply: Thank you for your comments. To verify that we have selected for patients with some form of traumatic injury as opposed to other etiologies, any ICD10 code diagnosis starting with S (i.e. injury) was selected for within our patient subset. This further confirms our intended patient population is presenting with AA subluxation secondary to traumatic causes.

Reviewer D

This is a investigative study of prevalence of neurological deficit, complications, and outcomes of patients diagnosed with AARS undergoing cervical fusion (CF) versus those treated without CF using National database. The authors concluded that adult patients undergoing CF for AARS demonstrated an increase in healthcare resource utilization but also a significant decrease in mortality. Extent of acute injury appears to have a strong influence on decision making for CF. This article is well-written

Reply: Thank you for your feedback.

Reviewer E

Spirollari et al. Analyzed atlantoaxial rotary subluxation (AARS) in adults. Some patients were treated with cervical fusion, the remaining were treated with non-CF. The later is not clearly described. **Did the patients receive a stiff collar or a soft collar, or no collar at all? The procedure of CT is not clearly described: Magerl Technique, pedical screws with internal fixator. Spondy-lodesis with allograft bone substitute material?**

Reply: As a consequence of the limitations inherent to the NIS database, patient imaging reports are unavailable, intraoperative planning is not defined, and there exists no description of specific

surgical techniques used to fuse. However, within these limitations we believe our study provides valuable knowledge on the treatment of AARS in the hospital setting. We show that primary fusion of patients is associated with favorable outcomes as evaluated by the variables available in the NIS dataset (mortality, complications, etc.).

Why is so much data presented as supplementary data? Is it not essential?

Reply: Thank you for this suggestion. To further elucidate our methodology, we have updated the body of our Methods section to include the essential ICD10 codes used for patient selection. The supplementary tables in this study serve as a convenient reference for the other codes included in our analysis of the selected patient population.

Changes in the text: Page 5 Methods, Lines 23-24

The authors conclude that the association of non-CF management of AARS was seen with increased injury severity and more damaging mechanisms. **But in the results' section, all 5 patients with myelopathy received fusion. Nevertheless, 15 Patients were treated without CF (and thus without laminectomy?) although they had neurologic symptoms (plegia).**

Reply: The neurologic symptoms of myelopathy, plegia, and bowel bladder dysfunction analyzed do not correlate to injury severity. In this study, severity of injury was defined specifically by using DRG codes that identify injury or trauma.

Frankly, I do not understand the paper. The methods are unclear. The paper has no message. Patient selection appears to be at random. **How come patients with AARS and neurology were not surgically treated?**

Reply: In this study, neurologic deficits seen are unable to be attributed to AARS. As a limitation of the NIS database, there does not exist a temporal relation between diagnostic codes, and thus it is not possible to rule out other potential etiologies of neurologic deficit. Additionally, as the majority of patients with AARS were neurologically intact, this does not lend towards decision making for surgical treatment. We report neurologic findings in our study for the sake of comprehensiveness and to further show that AARS patients are rarely neurologically injured. The overall message of our study is that in a population of trauma patients with cervical spine injury/dislocation, AARS is managed surgically in patients with better clinical status and is associated with less mortality. When associated with severe injury, AARS has higher mortality. Mechanism of injury and severity of trauma are important considerations for the treatment of AARS.

Reviewer F

Adult Atlantoaxial Rotatory Subluxation is extremely rare with only 25 cases reported according to a literature review by Horsfall et al. (1) in 2020. The number reported by the authors is very unusual. In reviewing the methodology of their research paper they used a nonspecific ICD CODE 10 S13.120,(2) This code includes all c1&c2 joint abnormalities and is not exclusive for rotatory subluxation.

The methodology is faulty and all what follows is irrelevant

1- Horsfall HL, Gharooni AA, Al-Mousa A, Shtaya A, Pereira E. Traumatic atlantoaxial rotatory subluxation in adults - A case report and literature review. Surg Neurol Int. 2020;11:376. Published 2020 Nov 6. doi:10.25259/SNI_671_2020

2-<https://icdlist.com/icd-10/S13.120A>.

Reply: Thank you for your input and feedback. There are key distinctions between Horsfall et al. and our current study. The cited article is a case report with a review of reported literature, while our analysis is a nationwide query using the largest publicly available US inpatient database. This offers a much larger sample size and explains the discrepancy seen in our sample compared to Horsfall et al, given that we are utilizing a different data source. To elucidate this, we have added more information on our data source in the Methods section. Regarding the use of the ICD10 code S13.120, it captures exclusively “subluxation of C1/C2 cervical vertebrae” which offers the closest diagnosis possible to AARS using ICD 10 coding. Importantly, this excludes other cervical vertebrae. As noted, additional analyses have also verified the traumatic nature of injury in our patient subset, further corroborating a diagnosis of AARS.

Changes in the text: Page 5 Methods, Lines 12-19

Reviewer G

The current study utilized national insurance database to compare patients with acute atlantoaxial rotatory subluxation and their outcomes after fusion or non-operative treatment. The 73% underwent conservative treatment. Among patients who had cervical fusion majority were myelopathic, had longer LOS and higher rate of pneumonia

Comments:

1. The ICD-10 diagnostic code is not specific to AARS only, it can be any type of dislocation. Is there an additional code that can be used to verify the eligibility of patients?

Reply: Thank you for your comments. The ICD-10 diagnostic code S13.120 captures exclusively “subluxation of C1/C2 cervical vertebrae” which offers the closest diagnosis possible to AARS using ICD 10 coding. Importantly, this excludes other cervical vertebrae. As noted, additional

analyses have also verified the traumatic nature of injury in our patient subset, further corroborating a diagnosis of AARS.

2. The severity of AARS and ICD-10 codes are not the same, to look at the type of AARS authors would need access to imaging which is not available through NIS database

Reply: As stated, the degree of AARS injury is unable to be evaluated without imaging, which is not available through the NIS database. However, within these limitations we describe severity of overall traumatic injury incurred by patients with the use of DRG codes, offering valuable knowledge of the extent of acute trauma and associated outcomes.

3. Given that majority of fusion patients were myelopathic authors would need to extend complications beyond 30 days

Reply: While the majority of myelopathic patients in our study received fusion treatment, only a small number of fusion patients presented with myelopathy (1.9%), and AARS patients overall were rarely neurologically injured (4.0%). As a limitation of the NIS database, our analysis is limited to the duration of the hospital stay, including only complications that arise within the hospitalization.

4. What were the non-CF treatments? How many patients crossed from non-fusion to fusion group? How did that impact outcomes and LOS?

Reply: Due to unreliable coding within the NIS, non-CF treatment modalities were not possible to ascertain in our patient sample. We queried our AARS patient-selected database for the treatments given to patients with non-surgical management. In practice, the treatment modality for non-surgical management would likely be cervical orthosis. However, in our query, using the diagnostic/procedural codes Z4689, F0DZ7EZ for orthosis, we found no corresponding results in our patient sample. Thus, these codes for non-surgical treatment management with cervical orthosis are likely unreliable and remain a limitation for this study. An additional note has been added to the limitation section pertaining to this. Additionally, in our study sample we found 40 patients had received laminectomy in the cervical spine, and 10 of these patients received isolated laminectomy without fusion, which was not significant. Crossover from non-fusion group to the fusion group is unable to be evaluated within the hospital stay because there are no reported commentaries or temporal relations for decision-making within the NIS.

Changes in the text: Page 12 Discussion, Lines 1-2

5. Authors should analyze reimbursements or actual costs, total charge is very often not clinically meaningful as it doesn't translate to what the actual cost was

Reply: Data of reimbursement or actual charge is not available specifically within the NIS database, and total charges is the only variable available. This value is a useful marker of healthcare resource utilization as referenced in numerous articles in the literature (2-5).