

Cervical spine injuries in adults ≥ 65 years after low-level falls – A systematic review and meta-analysis

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Abstract:

Background:

Older adults ≥ 65 are at risk of cervical spine (C-spine) injury, even after low-level falls. The objectives of this systematic review are to determine the prevalence of C-spine injury in this population and explore the association of unreliable clinical exam with C-spine injury.

Methods:

This systematic review will be conducted according to PRISMA guidelines. A search in MEDLINE, PubMed, EMBASE, Scopus, Web of Science, and the Cochrane Database of Systematic reviews will be conducted to include studies reporting on C-spine injury in adults ≥ 65 years after low-level falls. The primary outcome is C-spine injury. Two reviewers will independently screen articles, abstract data, and assess bias, and discrepancies will be resolved by a third reviewer. If data allows, a meta-analysis will be performed using a random effects model to determine the odds of C-spine injury with an unreliable clinical exam.

Discussion:

The results of the systematic review will be used to determine the prevalence of cervical spine injury in older adults ≥ 65 after low level falls and the association of unreliable clinical exam with C-spine injury. This will inform the development of a future clinical decision rule to guide C-spine imaging in adults ≥ 65 after low-level falls.

Keywords:

Spinal fractures, diagnostic imaging, aged, falls

1) Background/Literature Review:

By 2050, one-quarter of the population in Western countries will be over 65 years of age. (1) There has been a rapid increase in cervical spine fractures after ground level falls in older adults, with one study showing an increase in crude incidence from 5.2/100,000 in 1970 to 17.6/100,000 in 2011. (2) Three studies have described cervical spine fractures after ground level falls in patients ≥ 65 years and found a prevalence of 1.4% - 3.9% (Appendix I). (3-5) There is also considerable mortality associated with cervical spine fractures in older adults, with a recent study showing mortality rates of 12% at 3 months, 17% at 1 year, and 21% at 2 years. (6) The most common fracture patterns in older adults who fall are high cervical spine fractures including atlanto-occipital complex or odontoid fractures, which may explain the high mortality in this population. (7,8) There is clearly a risk of cervical spine fractures in older adults, even after low-level falls, and these injuries and their associated mortality are becoming more common over time.

The decision to order cervical spine imaging in older adults after trauma is fraught with difficulty. Literature suggests that up to 1/5 older adults with cervical spine fractures will not have neck pain or neck tenderness, which limits utility of the physical exam. (7) Potential under-diagnosis in this population seems likely, particularly given recent literature highlighting this phenomenon in intracranial bleeds in older adults after low-level falls. (8) On the other hand, an overly cautious approach may lead to unnecessary investigations with little benefit. Routine pan-scans in 152 older adults after ground-level falls had a new finding in 96 (63%) cases, a minor change in treatment in 35 (23%), and a major change in management in only 3 (2%) cases. (9) In cervical spine injuries, a catch-all imaging approach could also result in a prolonged duration of immobilization in cervical spine collars which is associated with significant morbidity including increased pain, increased intracranial pressure, failed airway management, and pressure ulcers. (10) Given the implications of ordering cervical spine imaging in older adults, it is necessary to further investigate the prevalence of cervical spine injury in older adults after low-level falls to determine the scope of the problem.

Clinical decision rules exist to guide clinical practice regarding cervical spine imaging in trauma. The Canadian cervical spine rule has been found to have the best sensitivity and specificity and greatest impact on reducing resources utilization. (11,12) High-risk features identified by the Canadian cervical spine rule as mandating radiography included age ≥ 65 years, dangerous mechanism, and paresthesias in extremities. The Canadian cervical spine study included only patients at risk of cervical spine fracture due to having neck pain, or having all of the following: a visible injury above the clavicle, not being ambulatory, and sustaining a dangerous mechanism of injury. Therefore, patients with no neck pain after a low-level fall would not be included. Another population that has not been well characterized by existing cervical spine rules are older adults ≥ 65 years who cannot be cleared clinically because patients with a GCS < 15 were excluded from the Canadian cervical spine rule. Furthermore, one study investigating a different clinical decision rule did not perform well in patients aged ≥ 65 years, with a sensitivity of only 94.8%. (13) Due to gaps in current literature, one population of interest is patients aged ≥ 65 years with an unreliable clinical exam after a low-level fall.

There has been one preliminary study investigating a clinical decision rule for cervical spine fractures in older adults specifically. (14) This was a retrospective case-control study conducted in blunt trauma patients 65 years and older with cervical spine fractures compared to randomly selected control subjects without fracture. The prevalence of cervical spine fractures in this population was 104/3958 (2.6%). Composite predictors of fractures in this population included focal neurologic deficit (adjusted odds ratio, 17.7; 95% confidence interval [CI]: 3.8, 83.4), severe head injury (odds ratio, 3.2; 95% CI: 1.5, 7.1), high-energy mechanism (odds ratio 6.7; 95% CI: 3.1, 14.8), and moderate-energy mechanism (odds ratio 3.3; 95% CI: 1.3, 8.3). (14) However, this study included all mechanisms, not just low-level falls and patients with a focal neurologic deficit after a fall would mandate imaging regardless of age or mechanism. This again highlights the need for further research investigating the prevalence of cervical spine injuries in older adults after low level falls specifically.

The purpose of this systematic review to determine the prevalence of cervical spine injury in adults ≥ 65 years after low-level falls and the association of unreliable clinical exam with cervical spine injury.

2) Methods

Protocol and Registration

This systematic review will be conducted according to PRISMA-P guidelines. (15) Reporting will be according to the PRISMA statement for systematic reviews and meta-analyses. (16) The protocol will be registered in PROSPERO. The link is https://www.crd.york.ac.uk/PROSPEROFILES/276342_PROTOCOL_20211029.pdf

Search Strategy

A medical librarian will be recruited to assist with the search strategy according to PRESS guidelines. (17) MEDLINE, PubMed, EMBASE, Scopus, Web of Science, and the Cochrane Database of Systematic reviews will be searched. Several combinations of search terms will be run. One search will combine terms related to falls, older adults, and spine injuries. Another will search for spine clinical decision rules. A third will combine terms for older adults and low or ground level falls. The full search strategy can be found in Appendix II.

Eligibility Criteria

Original research articles will be included if they report on low-level fall or unwitnessed fall unlikely to be > 3 ft (fall on level ground, fall from one or two steps, or a fall off a bed, chair, or toilet) in adults age ≥ 65 years. The primary outcome of the article must be (i) cervical spine injury (any cervical spine fracture, dislocation, or ligamentous injury) or all spine injuries with cervical spine injury prevalence available in manuscript or a

clinical decision rule investigating cervical spine injury AND data must be available on low-level falls in adults ≥ 65 years or by contacting authors OR (ii) population of study is adults ≥ 65 years after low level falls AND manuscript reports on prevalence of cervical spine injury or cervical spine injury data is available by contacting authors. Articles will be excluded if they are not primary literature (case reports, editorials, systematic reviews), patients age < 65 , fall >3 ft or high-risk mechanism (motor vehicle collision, bicycle accident, pedestrian struck by vehicle, all-terrain vehicle accident), or cervical spine injury prevalence is not available (number of cervical spine injuries in adults ≥ 65 years after low-level fall / number of adults ≥ 65 years who sustained a low-level fall). Articles will not be restricted by language. Articles will be included from inception until September 13, 2021. Articles will not be restricted based on language.

Screening

An initial review of titles and abstracts will be conducted and duplicate articles will be removed. Original articles will be uploaded into Covidence ©. Two investigators will independently screen titles and abstracts for inclusion based on eligibility criteria and additional duplicate titles and abstracts will be removed (JM, JM). Discrepant articles will be reviewed by a third reviewer (CF). Articles included based on title and abstract screen will undergo a full text review for eligibility and any additional duplicate full texts will be removed. If the article does not stratify the primary outcome based on age, mechanism, or spine injury type, authors will be contacted to determine if the stratified data is available. If data regarding reliability of clinical exam is not available, the article will be included in the primary outcome analysis but excluded from the secondary outcome analysis. If an abstract-only version is available, authors will be contacted regarding publication of the study. If the study has not undergone peer review and has not been accepted for publication it will be excluded. References of included papers will be screened for studies for possible inclusion that were missed using the search criteria. Included studies that use the same dataset will be counted as one study. If two studies use overlapping cohorts, the study with the larger cohort will be included.

Outcomes:

The primary outcome of this study is C-spine injury, defined as C-spine fracture, dislocation, or ligamentous injury in adults ≥ 65 years after low-level fall. The primary outcome measure will be calculated as number of cervical spine injuries in adults ≥ 65 years after low-level fall / number of adults ≥ 65 years who sustained a low-level fall. If data regarding reliability of clinical exam are available, the exposure of interest is unreliable clinical exam compared to reliable clinical exam. Unfortunately, there is no gold standard for unreliable clinical exam. For the purpose of this systematic review, unreliable clinical exam is defined as GCS < 15 or disoriented or unable to provide history. Reliable clinical exam is defined as GCS=15, oriented, and able to provide history. If data regarding reliability of clinical exam is unavailable, the proportion of patients age ≥ 65 years after low-level fall sustaining a C-spine injury will be reported.

Data Extraction:

Covidence © will be used to extract data. Two reviewers will independently extract data. Disagreements will be resolved by a third reviewer. Extracted data will include publication details (author, year of publication, country, journal), study details (study design, inclusion and exclusion criteria, age, number of patients, funding source), and outcomes (cervical spine injury, cervical spine injury in reliable v/s unreliable clinical exam).

Data Synthesis and Analysis:

Clinical heterogeneity will be assessed based on the inclusion and exclusion criteria of each study. If two studies are judged to be clinically homogeneous, they will be pooled to determine the primary outcome measure of prevalence of cervical spine injury in adults ≥ 65 years after low-level fall. When two studies are judged to be clinically homogeneous and report on the outcome of cervical spine injury based on reliability of clinical exam (unreliable v/s reliable), a meta-analysis will be conducted using a random effects model to determine the odds of cervical spine injury in patients with an unreliable clinical exam. In order to pool studies reporting on reliable clinical exam, the definition of reliable v/s unreliable clinical exam will need to be clinically homogeneous. We will report odds ratios and 95% confidence intervals. Statistical heterogeneity will be assessed using the I^2 statistic. If the I^2 statistic is higher than 75%, we will explore possible sources of heterogeneity. Sensitivity analyses will be performed, omitting studies judged to be at high level of bias, omitting graphically identified outliers, or using fixed effects. Review manager 5.1 (Copenhagen: The Nordic Cochrane Center, The Cochrane Collaboration, 2014) will be used for the statistical analysis. (18)

Risk of bias:

It is likely that most studies will be cohort studies. Risk of bias will be assessed using the Newcastle-Ottawa Scale for cohort studies. (19)

Timeline:

The protocol will be submitted to PROSPERO by the end of early fall 2021. Screening and data extraction will be performed in Fall 2021. Data will be analyzed and the manuscript produced in Winter 2021. Results will be presented in early spring 2022.

4) References

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Appendix I: Summary of studies investigating Cervical spine fractures after ground level falls

| | Design | Inclusion | Exclusion | Outcome |
|-----------------------|---|--|--|--|
| Benayoun et al (2016) | Retrospective health records review March 1 – Aug 31, 2014 | (1) documented evaluation in the ED for a history of ground level fall (defined as <3 ft or 5 stairs) and (2) a patient undergoing a Cervical spine CT | (1) a fall greater than 3 ft or greater than 5 stairs, (2) a fall accompanied by axial loading to the spine (whenever such a mechanism was clearly documented in the medical record), (3) age less than 16 years, (4) a patient found down at the scene of unknown etiology/ indeterminate mechanism, and (5) other mechanisms of trauma, such as penetrating gunshot/stab wound, motor vehicle collision, pedestrian struck by a moving vehicle, or a bicycle accident. | 199 patients ≥ 65 5 had Cervical spine fractures 5 / 199 = 2.5% |
| Evans et al (2015)* | Retrospective cohort study May 2008 – May 2013 | 65 years or older and were triaged to the trauma bay for fall. This included falls from standing/sitting/lying, falls down stairs, falls from a height, and patients “found down.” | Transfer from an outside facility for trauma evaluation Triaged to the main ED and then were later found to have injuries requiring trauma service consultation. | 482 patients falls from standing or less 19 Cervical spine fractures 19 / 482 = 3.9% |
| Tran et al (2016)* | Prospective observational cohort study. Convenience sample | 65 years of age or older and presented to the ED with a complaint related to a fall. Additionally, patients were required to be at baseline neurologic status as per their family member or chronic care facility staff. | Patients were excluded if they met major trauma criteria and were triaged to the trauma bay or if they were determined to have an acute change in baseline neurologic functioning as per the physician caring for the patient, including clinical intoxication. | 798 falls from standing or less 11 Cervical spine fractures 11/789 = 1.4% |

*Authors contacted for relevant results as they were not available in the published study

Appendix II: Search criteria Embase

1 Accidental Falls/ 65449
2 (falling or falls).tw,kf. or fall.ti. 205476
3 1 or 2 232042
4 exp *Aged/ 86697
5 (elderly or seniors or geriatric or older person* or older adult* or older women or older men).tw,kf. 979748
6 (septuagenarian* or Octogenarian* or Nonagenarian* or Sexagenarian*).tw,kf. 13488
7 (older adj2 patient*).tw,kf. 177777
8 or/4-7 1138005
9 3 and 845592
10 exp Spinal Injuries/ 78615
11 ((cerv* or verteb*) adj5 (spin* adj2 (injur* or fracture*))).tw,kf. 15150
12 ((cspin* or c spin* or atlas) adj2 (injur* or fracture*)).tw,kf. 930
13 exp Cervical Vertebrae/in [Injuries] 8149
14 or/10-13 90003
15 9 and 14 849
16 exp Aged/ 6703300
17 (elderly or seniors or geriatric or older person* or older adult* or older women or older men).tw,kf. 979748
18 (septuagenarian* or Octogenarian* or Nonagenarian* or Sexagenarian*).tw,kf. 13488
19 (older adj2 patient*).tw,kf. 177777
20 or/16-19 7042932
21 (((low level or ground) adj3 fall*) or low fall*).tw,kf. 1877
22 20 and 21 879
23 exp Spinal Injuries/ 78615
24 ((cerv* or verteb*) adj5 (spin* adj2 (injur* or fracture*))).tw,kf. 15150
25 ((cspin* or c spin* or atlas) adj2 (injur* or fracture*)).tw,kf. 930
26 exp Cervical Vertebrae/in 8149
27 or/23-26 90003
28 (validation or validate).tw,kf. 817972
29 27 and 28 869

30 15 or 22 or 29 2513
31 exp animals/ not humans/ 17568221
32 30 not 31 1849
33 32 use medall 863
34 falling/70311
35 (falling or falls).tw. or fall.ti. 203895
36 34 or 35 233235
37 exp *aged/ 86697
38 (elderly or seniors or geriatric or older person* or older adult* or older women or older men).tw. 962286
39 (septuagenarian* or Octogenarian* or Nonagenarian* or Sexagenarian*).tw. 13078
40 (older adj2 patient*).tw. 177292
41 or/38-40 1095313
42 36 and 41 44075
43 *spine fracture/ or cervical spine injury/ or cervical spine fracture/ 19262
44 ((cerv* or verteb*) adj5 (spin* adj2 (injur* or fracture*))).tw. 14581
45 ((cspin* or c spin* or atlas) adj2 (injur* or fracture*)).tw. 891
46 exp cervical vertebra/ and injury/ 122
47 or/43-46 30980
48 42 and 47 350
49 exp *aged/ 86697
50 (elderly or seniors or geriatric or older person* or older adult* or older women or older men).tw. 962286
51 (septuagenarian* or Octogenarian* or Nonagenarian* or Sexagenarian*).tw. 13078
52 (older adj2 patient*).tw. 177292
53 or/49-52 1123691
54 ((low level or ground) adj3 fall*).tw. 1338
55 low fall*.tw. 530
56 54 or 55 1863
57 53 and 56 562
58 *spine fracture/ or cervical spine injury/ or cervical spine fracture/ 19262
59 ((cerv* or verteb*) adj5 (spin* adj2 (injur* or fracture*))).tw. 14581
60 ((cspin* or c spin* or atlas) adj2 (injur* or fracture*)).tw. 891

| | | |
|----|---|----------|
| 61 | exp cervical vertebra/ and injury/ | 122 |
| 62 | or/58-61 | 30980 |
| 63 | (validation or prediction).tw. | 1164663 |
| 64 | 62 and 63 | 590 |
| 65 | 48 or 57 or 64 | 1442 |
| 66 | (exp animal/ or nonhuman/) not exp human/ | 12326902 |
| 67 | 65 not 66 | 1430 |
| 68 | 67 use emczd | 1008 |
| 69 | 33 or 68 | 1871 |