Pediatric Prehospital Protocols Grant
Cervical Spine Immoblization
Evidence-Based Practice Summary

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ASK THE QUESTION

Question 1: For pediatric patients in the prehospital setting, what are the specific risk factors for cervical spine (c-spine) injury (CSI) that can be used to create a selective spinal immobilization protocol?

Question 2: For stable, alert, non-cooperative pediatric trauma patients in the prehospital setting, do the potential benefits of full spinal immobilization outweigh the potential harm of physiological and/or psychological injury secondary to forced immobilization?

Question 3: For pediatric patients with suspected cervical spine injury in the prehospital setting, what are the most age-appropriate methods of inline spinal immobilization to minimize harm?

Question 4: For pediatric trauma patients in the prehospital setting, can EMS providers accurately apply criteria for clearing cervical spines in the field?

Search Strategy

A comprehensive literature search was conducted to find relevant evidence to support the Prehospital Protocols – C-Spine Clearance. This search was conducted in May 2012 and included the following databases and websites: Cochrane Collaboration Database, Agency for Healthcare Research and Quality (AHRQ), National Guideline Clearinghouse, PubMed, Trip Database, American Academy of Pediatrics, Prehospital Emergency Care, Prehospital and Disaster Medicine, Annals of Emergency Medicine, The American Journal of Emergency Medicine, Academic Emergency Medicine, JEMS: A Journal of EMS, Pediatric Emergency Care, and the Canadian Journal of Emergency Medicine. Search terms included the following: spine OR spinal, selective AND/OR full spinal immobilization protocol, immobilization, spinal injury, forced immobilization, secondary injury, immobilization benefits, age-appropriate inline spinal immobilization, cervical spinal injury, cervical spine clearance, clearance criteria, pediatric, children, prehospital, out of hospital, and emergency care. Limits placed on the initial search terms were for literature published within the last 10 years, pediatric patients including 0-18 years of age, human patients and within the English language. Searches were expanded to include adults if pediatric data was lacking.

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CRITICALLY ANALYZE THE EVIDENCE

Existing External Order Sets/Guidelines/Clinical Pathways

External Guideline/ Pathway/Order Set	Organization and Author	Last Update
None		

Question 1: For pediatric patients in the prehospital setting, what are the specific risk factors for cervical spine injury that can be used to create a selective spinal immobilization protocol?

Recommendation: When considering the development of a selective spinal immobilization protocol in pediatrics, patients with any of the following criteria should be immobilized: GCS < 15, focal neurologic findings, neck pain in children > 2 years, limited movement of the neck, substantial torso (clavicle, abdomen, flank, back, or pelvis) injury, diving injury, high-risk (head-on, rollover, ejection, death in vehicle, speed > 55 mph) motor vehicle collision, evidence of intoxication, or the presence of a painful distracting injury.

Strength of Recommendation: Strong
Grade Criteria: Moderate quality evidence

Eight observational studies were found that addressed the PICO question. Several large, multicenter trials conducted in adults assessed whether the absence of specific clinical criteria could be used by EMS practitioners to clear patients with c-spine injuries. In adults, the sensitivity of clinical criteria to identify patients with c-spine injuries ranged from 91-99% (Domeier 1997, Domeier 2005, Stroh 2011, Werman 2007). The criteria most commonly used in such protocols included: altered mental status, neurologic deficit, spinal pain or tenderness, evidence of intoxication, and suspected bone extremity fracture. A large, prospective trial of pediatric patients validated the following criteria to be predictors of c-spine injuries, based on criteria initially derived in adults: midline cervical tenderness, altered level of alertness, evidence of intoxication, neurologic abnormality, and the presence of a painful distracting injury (Viccellio 2001).

The Viccellio study did not seek to find uniquely associated features in the pediatric population, yet a study by Leonard et al. did do this, In this case-control study (540 cases, 1060 controls) of pediatric patients younger than 16 years presenting to the hospital after blunt trauma, 8 factors were associated with c-spine injury: altered mental status, focal neurologic findings, neck pain, torticollis, substantial torso injury, diving, and high-risk motor vehicle crash. Another retrospective study of pediatric patients less than 3 years old found the following to be independent predictors of c-spine injuries: GCS >/= 14, involvement in a motor vehicle collision, GCS_{EYE} equal to 1, and age > 2 years (Pieretti-Vanmarcke 2009). Older age was also found to be a predictor for c-spine injury in a large retrospective review of pediatric patients admitted to the hospital following blunt trauma. The adjusted risk for CSI increased 2-fold in preadolescents, and 5-fold in adolescents (Mohseni 2011).

If it is assumed that immobilization should occur only for those patients at risk for c-spine injuries, then consideration of the factors above should be made when deciding whether to immobilize a pediatric patient.

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Recommendation(s): Moderate Quality Evidence
Number of Studies: Total # 8 ☐ Systematic review ☐ RCT ☒ Observational (Domeier 1997, Domeier 2005, Leonard 2011, Mohseni 2011, Pieretti-Vanmarcke 2009, Stroh 2001, Viccellio 2001, Werman 2007) ☐ Case Reports Publication Bias Evident ☐ Yes ☒ No

Design *Limitations*	Summary of *Consistency*	*Indirectness* of Comparison	*Imprecision* of Results
☐ None ☒ Insufficient sample size (Domeier 1997, Pieretti-Vanmarcke) ☒ Lack of blinding (Domeier 1997, Domeier 2005, Leonard, Mohseni, Pieretti-Vanmarcke, Stroh, Viccellio, Werman) ☒ Lack of allocation concealment (Domeier 1997, Domeier 2005, Leonard, Mohseni, Pieretti-Vanmarcke, Stroh, Viccellio, Werman) ☐ Large losses to F/U ☐ Incorrect analysis of ITT ☐ Stopped early for benefit ☐ Selective reporting of measured outcomes (e.g., no effect outcome)	☒ No inconsistencies (Leonard, Mohseni, Pieretti-Vanmarcke,Viccellio) ☐ Wide variation of treatment effect across studies ☒ Populations varied (e.g., sicker, older) (Domeier 1997, Domeier 2005, Werman, Stroh) ☐ Interventions varied (e.g., doses) ☐ Outcomes varied (e.g., diminishing effect over time)	☒ Head-to-head comparison in correct population (Leonard, Mohseni, Pieretti-Vanmarcke, Vicellio) ☐ Indirect comparisons (e.g., interventions to placebo but not each other) ☒ Different populations (Domeier 1997, Domeier 2005, Stroh, Werman) ☐ Different interventions ☐ Different outcomes measured ☐ Comparisons not applicable to question/outcome	**Dichotomous outcomes** ☐ Sample size lower than calculated optimal information size ☒ Total # of events is < 300 based on simulations & dependent on baseline risk & effect sizes (Domeier 1997, Pieretti-Vanmarcke) ☐ 95% CI includes negligible effect and appreciable benefit or harm **Continuous outcomes** ☐ 95% CI includes no effect and the upper or lower limit crosses the minimal important difference (MID), either for benefit or harm ☐ Upper or lower limit crosses an effect size of 0.5 in either direction (if MID is not known or differences in outcomes require the calculation of an effect size)

Sample	CI/RR
Domeier (1997): Multicenter, prospective observational study to assess whether absence of clinical criteria (altered mental status, neurologic deficit, spinal pain or tenderness, evidence of intoxication, and suspected bone extremity fracture) can identify EMS trauma patients without significant spinal injury. Study included data on 291 adult patients.	**Domeier (1997):** • Spinal injury was identified by the presence of ≥ 1 criteria for 277 of 291 (95.2%) patients
Domeier (2005): Prospective, observational study of 415 patients with spinal injuries. The study was meant to assess whether the absence of the following clinical criteria could be used for spinal clearance: evidence of intoxication, neurologic deficit, suspected extremity facture and spine pain or tenderness.	**Domeier (2005):** • Sensitivity of spine injury assessment was 91% (95% CI: 88.3-93.8%) • 8% of patients with spine injuries were immobilized • None of the nonimmobilized patients sustained cord injuries • Specificity of the assessment was 40.1% (95% CI: 39.2-40.9%)
Leonard (2011): Case-control study (540 cases, 1060 controls) of pediatric patients younger than 16 years presenting to the hospital after blunt trauma, and who received c-spine radiographs. The purpose of the study was to id risk factors associated with c-spine injury in children after blunt trauma.	**Leonard (2011):** • The authors identified 8 factors associated with c-spine injury: altered mental status, focal neurologic findings, neck pain, torticollis, substantial torso injury, diving, and high-risk motor vehicle crash • Having 1 or more factors was 98% (95% CI: 96-99%) sensitive and 26% (95% CI: 23-29%) specific for c-spine injury
Mohseni (2011): Retrospective review of 240,674 pediatric patients admitted to the hospital following blunt trauma. The objective of the study was to categorize the incidence and risk factors for CSI in different pediatric developmental ages.	**Mohseni (2011):** • 1.3% of patients (n = 3035) sustained a CSI • The incidence of CSI in the stratified age groups was: 0.4% in infants/toddlers; 0.4% in preschool/young children; 0.8% in preadolescents and 2.6% in adolescents • The adjusted risk for CSI increased 2-fold in preadolescents and 5-fold in adolescents
Pieretti-Vanmarcke (2009): Retrospective observational study of 83 patients </= 3 years with CSI. The objective of the study was to assess whether clinical criteria could be used to rule out CSI in patients younger than 3 years (Glasgow Coma Score <14, GCSEYE < 14, motor	**Pieretti-Vanmarcke (2009):**

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vehicle crash, and age 2 years or older).

Stroh (2001): Retrospective observational study of 861 adult and pediatric patients with cervical spinal injuries. The study was meant to assess whether the absence of the following clinical criteria could be used for spinal clearance: spinal pain or tenderness, significant multiple system trauma, severe head or facial trauma, numbness or weakness in any extremity after trauma, and altered mental stutus.

Viccellio (2001): Prospective, multicenter trial of 3065 pediatric patients to evaluate incidence of spinal injury in children. The presence or absence of the following criteria was noted: midline cervical tenderness, altered level of alertness, evidence of intoxication, neurologic abnormality, and presence of painful distracting injury.

Werman (2007): Prospective observational study of 329 trauma patients >/= 16 years who were transported via medical air lift to a hospital. Medical crews used the absence of the following criteria for spinal clearance: abnormal level of consciousness, evidence of intoxication, distracting painful injury, spinal tenderness or pain, or abnormal neurologic examination.

TABLE 3. Independent Predictors of Cervical Spine Injury

Variable	Odds Ratio	95% CI	*p*
GCS ≥14	12.5	5.0–31.6	<0.001
MVC	5.1	2.8–9.0	<0.001
GCS_{EYE} = 1	6.9	3.4–14.2	<0.001
Age >2 yr	2.2	1.2–4.0	<0.001

Stroh (2001):
- Sensitivity of the spine immobilization protocol was 99% (95% CI: 97.7-99.7%)
- One 9 month old female with CSI was not identified by the protocol

Viccellio (2001):
- The decision rule correctly identified all pediatric CSI victims (sensitivity 100%; 95% CI: 87.8-100%), and correctly designated 603 patients as low risk for CSI (negative predictive value: 100%; 95% CI: 99.4-100%)

Werman (2007):
- The algorithm had a sensitivity of 90%, and a specificity of 16%

Table 4 Sensitivity and Specificity of Individual Criterion for Presence of Spinal Injury

	Sensitivity (95% CI)	Specificity (95% CI)	Positive Predictive Value (95% CI)	Negative Predictive Value (95% CI)
Back pain	28 (16–43)	93 (89–58)	41 (25–59)	88 (83–91)
Intoxication	24 (13–38)	75 (70–80)	15 (8–25)	84 (79–89)
GCS <15	42 (22–50)	56 (50–62)	12 (7–19)	83 (76–88)
Abnormal neuro	57 (42–71)	52.2 (46–58)	18 (12–24)	82 (75–87)
Distracting injury	49 (34–64)	38 (33–44)	12 (8–18)	81 (73–87)
All	90 (76–97)	16 (12–21)	13 (9–17)	92 (80–98)

GCS, Glasgow Coma Scale.

References:

Domeier, R. (1997). 1997 SAEM Annual Meeting Abstracts. *Academic Emergency Medicine, 4*(5), 342-519 (435 this reference).
Domeier, R. M., Frederiksen, S. M., & Welch, K. (2005). Prospective performance assessment of an out-of-hospital protocol for selective spine immobilization using clinical spine clearance criteria. *Annals of Emergency Medicine, 46*(2), 123-131.
Leonard, J. C., Kuppermann, N., Olsen, C., Babcock-Cimpello, L., Brown, K., Mahajan, P., et al. (2011). Factors associated with cervical spine injury in children after blunt trauma. *Annals of Emergency Medicine, 58*(2), 145-155.
Mohseni, S., Talving, P., Branco, B. C., Chan, L. S., Lustenberger, T., Inaba, K., et al. (2011). Effect of age on cervical spine injury in pediatric population: A National Trauma Data Bank review. *Journal of Pediatric Surgery, 46*(9), 1771-1776.
Pieretti-Vanmarcke, R., Velmahos, G. C., Nance, M. L., Islam, S., Falcone, R. A., Jr., Wales, P. W., et al. (2009). Clinical clearance of the cervical spine in blunt trauma patients younger than 3 years: A multi-center study of the American Association for the Surgery of Trauma. *Journal of Trauma, 67*(3), 543-549.
Stroh, G., & Braude, D. (2001). Can an out-of-hospital cervical spine clearance protocol identify all patients with injuries? An argument for selective immobilization. *Annals of Emergency Medicine, 37*(6), 609-615.
Viccellio, P., Simon, H., Pressman, B. D., Shah, M. N., Mower, W. R., Hoffman, J. R., et al. (2001). A prospective multicenter study of cervical spine injury in children. *Pediatrics, 108*(2), e20.
Werman, H., White, L., Herron, H., Depee, S., Love, L., Betz, S., et al. (2008). Clinical clearance of spinal immobilization in the air medical environment: A feasibility study. *J Trauma, 64*(6), 1539-1542.

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Question 2: For stable, alert, non-cooperative pediatric trauma patients in the prehospital setting, do the potential benefits of full spinal immobilization outweigh the potential harm of physiological and/or psychological injury secondary to forced immobilization?

Recommendation: Due to the risk of severe secondary injury or death, alternative means to minimize spinal movement during transport or no immobilization at all should be considered in situations when cervical collar placement has the potential to result in more neck movement than no immobilization at all.

Strength of Recommendation: Strong
Grade Criteria: Very low quality evidence

There were no relevant articles found directly addressing the PICO question. However, a number of studies conducted among adult patients found immobilization to be associated with a number of adverse effects.

One observational study among adult patients with blunt trauma found there was less neurologic disability among trauma patients who were not immobilized compared to those patients who were (Hauswald 1998), and a second retrospective review of adult patients with c-spine trauma found that c-spine immobilization was associated with an increased risk of death (Vanderlan 2009). Lastly, a systematic review of 17 RCTs found there to be adverse effects associated with immobilization (e.g., increased respiratory rate, skin ischemia, pain and discomfort) (Kwan 2005).

Recommendation(s): Very Low Quality Evidence
Number of Studies: Total # 3 ☒ Systematic review [(Kwan 2005)] ☐ RCT ☒ Observational [(Hauswald 1998, Vanderlan 2009)] ☐ Case Reports Publication Bias Evident ☐ Yes ☒ No

Design *Limitations*	**Summary of *Consistency***	***Indirectness* of Comparison**	***Imprecision* of Results**
☐ None ☒ Insufficient sample size [(Vanderlan 2009)] ☒ Lack of blinding [(Hauswald 1998, Vanderlan 2009)] ☒ Lack of allocation concealment [(Hauswald 1998, Vanderlan 2009)] ☐ Large losses to F/U ☐ Incorrect analysis of ITT ☐ Stopped early for benefit ☐ Selective reporting of measured outcomes (e.g., no effect outcome)	☐ No inconsistencies ☐ Wide variation of treatment effect across studies ☒ Populations varied (e.g., sicker, older) [(Hauswald 1998, Vanderlan 2009)] ☐ Interventions varied (e.g., doses) ☐ Outcomes varied (e.g., diminishing effect over time)	☐ Head-to-head comparison in correct population ☐ Indirect comparisons (e.g., interventions to placebo but not each other) ☒ Different populations [(Hauswald 1998, Kwan 2005, Vanderlan 2009)] ☐ Different interventions ☒ Different outcomes measured [(Hauswald 1998, Kwan 2005, Vanderlan 2009)] ☒ Comparisons not applicable to question/outcome [(Hauswald 1998, Kwan 2005, Vanderlan 2009)]	**Dichotomous outcomes** ☒ Sample size lower than calculated optimal information size [(Vanderlan 2009)] ☒ Total # of events is < 300 based on simulations & dependent on baseline risk & effect sizes [(Vanderlan 2009)] ☐ 95% CI includes negligible effect and appreciable benefit or harm **Continuous outcomes** ☐ 95% CI includes no effect and the upper or lower limit crosses the minimal important difference (MID), either for benefit or harm ☐ Upper or lower limit crosses an effect size of 0.5 in either direction (if MID is not known or differences in outcomes require the calculation of an effect size)

Sample	**CI/RR**
Hauswald (1998): A 5-year retrospective chart review of 545 patients with blunt traumatic spinal or spinal cord injuries was conducted at 2 different university hospitals to examine the effect of emergency immobilization on neurologic outcomes of patients. **Kwan (2005):** Systematic review of 17 RCTs of spinal immobilization on healthy participants. **Vanderlan (2009):** 199 charts of adult patients with penetrating cervical trauma at an urban charity	**Hauswald (1998):** • There was less neurologic disability in the unimmobilized patients (OR: 2.03, 95% CI: 1.03-3.99, p = 0.04) • Results were similar when the analysis was limited to patients with cervical injuries (OR: 1.52; 95% CI: 0.64-3.62, p = 0.34) **Kwan (2005):** • Adverse effects of spinal immobilization included a significant increase in respiratory rate, skin

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hospital were retrospectively reviewed to determine if c-spine immobilization was related to patient mortality.	ischemia, pain and discomfort (Results were not pooled for analysis) **Vanderlan (2009):** • 35 patient deaths were identified; c-spine immobilization was associated with an increased risk of death (p < 0.00, OR: 2.77, 95% CI: 1.18-6.49)

References:
Hauswald, M., Ong, G., Tandberg, D., & Omar, Z. (1998). Out-of-hospital Spinal Immobilization: Its effect on neurologic injury. *Academic Emergency Medicine, 5*(3), 214-219.
Kwan, I., & Bunn, F. (2005). Effects of prehospital spinal immobilization: a systematic review of randomized trials on healthy subjects. *Prehospital Disaster Medicine, 20*(1), 47-53.
Vanderlan, W. B., Tew, B. E., & McSwain Jr., N. E. (2009). Increased risk of death with cervical spine immobilisation in penetrating cervical trauma. *Injury, 40*(8), 880-883.

Question 3: For pediatric patients with suspected cervical spine injury in the prehospital setting, what are the most age-appropriate methods of inline spinal immobilization to minimize harm?

There were few relevant articles found directly addressing the PICO question. However, two of the studies included in the systematic review specifically evaluated the techniques utilized on pediatric patients as well as the respiratory effects of spinal immobilization (Huerta 1987; Schafermeyer 1991). Huerta (1987) found that cervical spine stabilization is best achieved when using a rigid-type cervical collar in combination with supplemental devices such as a Kendrick Extrication Device ® and half-spine board). Schafermeyer (1991) found that a child's respiratory capacity was significantly reduced during spinal immobilization and there was not a preferred strapping technique to resulted in improved outcomes. In addition, Herzenberg, et al. (1989) found that in younger children (< 7 years) extension was the proper position for reduction of injury which was further confirmed by Nypaver and Treloar (1994).

Recommendation: Children younger than 8 years old should be transported with elevation of the back or an occipitally recessed backboard to optimize neutral positioning of the cervical spine.

Strength of Recommendation: Weak
Grade Criteria: Low quality evidence

Recommendation(s): Low Quality Evidence **Number of Studies: Total #** ☒ Systematic review [Ahn 2011] ☐ RCT ☒ Observational [Nypaver 1994, Herzenberg 1989] ☐ Case Reports Publication Bias Evident ☐ Yes ☒ No			
Design *Limitations*	**Summary of *Consistency***	***Indirectness* of Comparison**	***Imprecision* of Results**
☐ None ☒ Insufficient sample size [Ahn 2011, Herzenberg 1989, Nypaver 1994] ☒ Lack of blinding [Anh 2011, Herzenberg 1989, Nypaver 1994] ☒ Lack of allocation concealment [Ahn 2011, Herzenberg 1989, Nypaver 1994] ☐ Large losses to F/U ☐ Incorrect analysis of ITT ☐ Stopped early for benefit ☐ Selective reporting of measured outcomes (e.g., no effect outcome)	☐ No inconsistencies ☐ Wide variation of treatment effect across studies ☒ Populations varied (e.g., sicker, older) [Ahn 2011, Herzenberg 1989, Nypaver 1994] ☒ Interventions varied (e.g., doses) [Ahn 2011, Herzenberg 1989, Nypaver 1994] ☐ Outcomes varied (e.g., diminishing effect over time)	☐ Head-to-head comparison in correct population ☐ Indirect comparisons (e.g., interventions to placebo but not each other) ☒Different populations Anh 2011 ☐ Different interventions ☐ Different outcomes measured ☐ Comparisons not applicable to question/outcome	**Dichotomous outcomes** ☒ Sample size lower than calculated optimal information size [Ahn 2011, Herzenberg 1989, Nypaver 1994] ☐ Total # of events is < 300 based on simulations & dependent on baseline risk & effect sizes ☐ 95% CI includes negligible effect and appreciable benefit or harm **Continuous outcomes** ☐ 95% CI includes no effect and the upper or lower limit crosses the minimal important difference (MID), either for benefit or harm ☐ Upper or lower limit crosses an effect size of 0.5 in either direction (if MID is not known or differences in outcomes require the calculation of an effect size)
Sample		**CI/RR**	

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Ahn (2011): 25 studies included 2 of which were specific to pediatrics Determined the current evidence available related to specific questions. 1.) What is the optimal type and duration of prehospital spinal immobilization in patients with acute spinal cord injury **Nypaver (1994):** N = 40 children < 8 years Prospective Determine the height of back elevation required to place the c-spine of children < 8 years in neutral position and whether agreement on the height required for neutral position could be reached by two independent observers Utilized standard size padding with or without shims to raise the back off of the backboard. **Herzenberg (1989):** N = 10 children < 7 years Prospective Investigate c-spine positioning through clinical, radiographic, and anthropometric studies.	**Ahn (2011):** • Immobilization in the prehospital setting should include a cervical collar, head immobilization, and a spinal board. • Patient should be transferred off of the board upon admission to a facility or if patients are awaiting a transfer. • Padded boards or inflatable bean bag boards should be utilized to reduce pressure on the occiput and sacrum. NOTE: Recommendations are intended for patients ≥ 12 years **Nypaver (1994):** • All children required elevation of the back for correct neutral position (mean height, 25.4 ± 6.7mm, 5 to 41 mm). • Children < 4 years required more elevation (27 ± 7.2 versus 22 ± 4.2mm, P < 0.05). **Herzenberg (1989):** • All 10 children, extension was the proper position for reduction of the injury of the c-spine. NOTE: Can be accomplished by a recess for the occiput to lower the head or a double mattress pad to raise the chest

References:

Ahn, H., Singh, J., Nathens, A., MacDonald, R., Travers, A., Tallon, J., et al. (2011). Pre-hospital care management of a potential spinal cord injured patient: A systematic review of the literature and evidence-based guidelines. *Journal of Neurotrauma, 28*(8), 1341-1361.

Huerta, C., Griffith, R., & Joyce, S. M. (1987). Cervical spine stabilization in pediatric patients: Evaluation of current techniques. *Annals of Emergency Medicine, 16*(10), 1121-1126.

Schafermeyer, R. W., Ribbeck, B. M., Gaskins, J., Thomason, S., Harlan, M., & Attkisson, A. (1991). Respiratory effects of spinal immobilization in children. *Annals of Emergency Medicine, 20*(9), 1017-1019.

Nypaver, M., & Treloar, D. (1994). Neutral cervical spine positioning in children. *Annals of Emergency Medicine, 23*(2), 208-211.

Herzenberg, J., Hensinger, R., Dedrick, D., & Phillips, W. (1989). Emergency transport and positioning of young children who have an injury of the cervical spine. The standard backboard may be hazardous. *The Journal of Bone and Joint Surgery (American), 71*(1), 15-22.

Question 4: For pediatric trauma patients in the prehospital setting, can EMS providers accurately apply criteria for clearing cervical spines in the field?

The Trauma Association of Canada Pediatric Subcommittee (2011) created a National Pediatric Cervical Spine Evaluation Pathway to evaluate the cervical spine in patients with a reliable clinical examination and in those with an unreliable examination. The committee found that it is possible to clinically clear the pediatric cervical spine in patients with a reliable clinical exam using a combination of the National Emergency X-Radiography Utilization Study (NEXUS) low-risk criteria and the Canadian C-Spine Rule (CCR) criteria. Albeit, this pathway was intended to be used by in-hospital providers however, some of the studies that were evaluated were conducted in a prehospital setting.
The research conducted in a prehospital setting supports this recommendation. However, most of the research included adults with very few pediatric patients represented.

Recommendation: Implementation of pediatric selective spinal immobilization protocols that have prehospital providers apply previously established risk criteria for cervical spine injury should be considered

Strength of Recommendation: Weak
Grade Criteria: Moderate quality evidence

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Recommendation(s): Moderate Quality Evidence
Number of Studies: Total # ☐ Systematic review ☐ RCT ☒ Observational (Armstrong 2007, Domeier 2005, Domeier 2002, Pieretti- Vanmarcke 2009, Stroh 2001, Vaillancourt 2009, Werman 2008) ☐ Case Reports
Publication Bias Evident ☐ Yes ☒ No

Design *Limitations*	Summary of *Consistency*	*Indirectness* of Comparison	*Imprecision* of Results
☐ None ☐ Insufficient sample size ☐ Lack of blinding ☐ Lack of allocation concealment ☐ Large losses to F/U ☐ Incorrect analysis of ITT ☐ Stopped early for benefit ☐ Selective reporting of measured outcomes (e.g., no effect outcome)	☐ No inconsistencies ☐ Wide variation of treatment effect across studies ☒ Populations varied (e.g., sicker, older) (Armstrong 2007, Domeier 2005, Domeier 2002, Stroh 2001, Vaillancourt 2009, Werman 2008) ☐ Interventions varied (e.g., doses) ☐ Outcomes varied (e.g., diminishing effect over time)	☒ Head-to-head comparison in correct population (Pieretti- Vanmarcke 2009) ☐ Indirect comparisons (e.g., interventions to placebo but not each other) ☒Different populations (Armstrong 2007, Domeier 2005, Domeier 2002, Stroh 2001, Vaillancourt 2009, Werman 2008) ☐ Different interventions ☐ Different outcomes measured ☐ Comparisons not applicable to question/outcome	**Dichotomous outcomes** ☐ Sample size lower than calculated optimal information size ☐ Total # of events is < 300 based on simulations & dependent on baseline risk & effect sizes ☐ 95% CI includes negligible effect and appreciable benefit or harm **Continuous outcomes** ☐ 95% CI includes no effect and the upper or lower limit crosses the minimal important difference (MID), either for benefit or harm ☐ Upper or lower limit crosses an effect size of 0.5 in either direction (if MID is not known or differences in outcomes require the calculation of an effect size)

Sample

Armstrong (2007): N = 103 adult
Prospective, observational
Determine whether the incidence of unnecessary c-spine immobilization by ambulance personnel could be safely reduced through the implementation of an evidence-based algorithm.

Domeier (2005): N = 13,357 adults/pediatric patients
Prospective, observational
Determine whether the use of an EMS protocol ^for selective spine immobilization would result in appropriate immobilization without spinal cord injury associated with nonimmobilization.
^ Eligible for spinal clearance based on the absence of all of the clinical findings:

- AMS
- Evidence of intoxication
- Neurologic deficit
- Suspected extremity fracture
- Spine pair or tenderness

Domeier (2002): N =8975 adults
Prospective, observational
Evaluate 5 prehospital clinical criteria- AMS, neurologic deficit, spine pain or tenderness, evidence of intoxication, or suspected extremity fracture

Meldon (1998): N = 190 adults
Prospective, observational

CI/RR

Armstrong (2007):

- 69 (67%) patients had their c-spines cleared at the scene with no adverse effects; 60 of these patients were discharged from the scene; 9 were taken the ED and all were discharged home
- 34 (33%) patients could not have their c-spines cleared; 4 (12%) self-discharged at scene and 30 (88%)were transported to the ED

Domeier (2008):

- 415 with injuries- 50 with SCI and 128 with cervical injuries
- 33 of the 415 (8%) were nonimmobilized with spine injuries
- Protocol had a sensitivity of 92% (95% CI; 89.4-94.6%) , specificity 40% (95% CI; 38.9-40.5%)

Domeier (2002):

- Spine injury was identified by the criteria in 280 out of 295 (94.9%).

Table 6 Statistical Summary for the "Overall Study Criterion": Has at Least One of the Five Prehospital Clinical Criteria Used in Detecting Spine Injury

	%	(95% Confidence Interval)
Sensitivity	94.9	(91.7–97.1)
Specificity	35.0	(34.0–36.0)
Positive predictive value	4.7	(4.2–5.3)
Negative predictive value	99.5	(99.2–99.7)

Meldon (1998):

- Overall disagreement between EMTs and Emergency Medicine physicians regarding out of hospital

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Determine the level of agreement between EMTs and Emergency Medicine physicians **Stroh (2001):** N = 504 adult/pediatric patients Retrospective Determine the sensitivity of the Fresno/Kings/Madera EMS selective spine immobilization protocol in identifying patients with potential cervical injuries. Spinal immobilization needed if: - Spinal pain or tenderness, including neck pain with a history of trauma - Significant multiple system trauma - Severe head or facial trauma - Numbness or weakness in any extremity after trauma - Loss of consciousness caused by trauma - If AMS (including drugs, alcohol, and trauma) and: No history available, found in setting of possible trauma, OR near drowning with a history of probability of diving. **Vaillancourt (2009):** N = 1949 adult patients Prospective, observational Evaluates the performance characteristics, reliability, and clinical sensibility of the Canadian C-Spine Rule (CCR) when used by paramedics in the out-of-hospital setting. **Werman (2008):** N = 329 adults Prospective, observational Determine the feasibility of applying prehospital algorithms^ in the ***air medical transport*** environment ^ Eligible for spinal clearance based on the absence of all of the clinical findings: - Abnormal LOC - Evidence of intoxication - Distracting painful injury - Spinal tenderness or pain - Abnormal neurologic examination	CSI clearance occurred in 44 patients (23%; kappa = 0.29; 95% CI: 0.15 - 0.43; P < 0.01). **Stroh (2001):** • 495 arrived in C-spine immobilization; 2 refused immobilization, 2 could not be immobilized, 3 were missed by protocol criteria, 2 were missed due to protocol violations • Protocol had a sensitivity of 99% (95% CI; 97.7-99.7%). **Vaillancourt (2009):** • Paramedics classified 12 important injuries with sensitivity 100% (95% CI; 74-100%), specificity 37.7% (95% CI; 6-40%) • In assessing the reliability of the CCR, the paramedic's interpretation of the CCR was 0.93 (95% CI: 0.87-0.99). **Werman (2008):** • 49 with SCI and 12 of those had injuries that were unstable • 40 patients met criteria for deferring stabilization, 4 of these had spinal fractures • Algorithm had a sensitivity of 90% (95% CI; 76-97%), specificity 16% (95% CI; 12-21%)

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