

Risk factors for adverse outcomes in older adults with blunt chest trauma: A systematic review

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ABSTRACT

Objectives: The objective of this study was to systematically review the published literature for risk factors associated with adverse outcomes in older adults sustaining blunt chest trauma.

Methods: EMBASE and MEDLINE were searched from inception until March 2017 for prognostic factors associated with adverse outcomes in older adults sustaining blunt chest trauma using a pre-specified search strategy. References were independently screened for inclusion by two reviewers. Study quality was assessed using the Quality in Prognostic Studies tool. Where appropriate, descriptive statistics were used to evaluate study characteristics and predictors of adverse outcomes.

Results: Thirteen cohort studies representing 79,313 patients satisfied our selection criteria. Overall, 26 prognostic factors were examined across studies and were reported for morbidity (8 studies), length of stay (7 studies), mortality (6 studies), and loss of independence (1 study). No studies examined patient quality of life or emergency department recidivism. Prognostic factors associated with morbidity and mortality included age, number of rib fractures, and injury severity score. Although age and rib fractures were found to be associated with adverse outcomes in more than 3 studies, meta-analysis was not performed due to heterogeneity amongst included studies in how these variables were measured.

Conclusions: While blunt chest wall trauma in older adults is relatively common, the literature on prognostic factors for adverse outcomes in this patient population remains inadequate due to a paucity of high quality studies and lack of consistent reporting standards.

chez les personnes âgées ayant subi un trauma thoracique contondant, dans les bases de données EMBASE et MEDLINE depuis leur début respectif jusqu'à mars 2017, à l'aide d'une stratégie de recherche prédéterminée. Les références ont fait l'objet d'une analyse particulière en vue de leur sélection dans l'étude, par deux examinateurs indépendants. La qualité des études a été évaluée à l'aide de l'outil Quality in Prognostic Studies, et nous avons eu recours, s'il y avait lieu, à des statistiques descriptives pour évaluer les caractéristiques des études et les facteurs prévisionnels de résultats défavorables.

Résultats: Treize études de cohorte, totalisant 79 313 patients, respectaient les critères de sélection. Dans l'ensemble, 26 facteurs pronostiques ont été examinés dans les études, au regard de la morbidité (8 études), de la durée du séjour (7 études), de la mortalité (6 études) et de la perte d'autonomie (1 étude). Par contre, aucune étude ne portait sur la qualité de vie des patients ou sur les retours au service des urgences. Les facteurs pronostiques associés à la morbidité et à la mortalité comprenaient l'âge, le nombre de côtes fracturées et le degré de gravité des lésions. Bien que l'âge et les fractures de côte soient ressortis comme des facteurs associés à des résultats défavorables dans plus de 3 études, nous n'avons pas procédé à une méta-analyse en raison de l'hétérogénéité des mesures de ces variables dans les études retenues.

Conclusions: Les traumas contondants de la paroi thoracique sont relativement fréquents chez les personnes âgées, mais la documentation sur les facteurs pronostiques de résultats défavorables dans cette population fait défaut en raison de l'insuffisance d'études de qualité et du manque d'uniformité dans la présentation des résultats.

Keywords: elderly, blunt chest trauma, rib fracture, outcomes

RÉSUMÉ

Objectif: L'étude consistait en un examen systématique de la documentation publiée sur les facteurs de risque associés à des résultats défavorables chez les personnes âgées ayant subi un trauma thoracique contondant.

Méthode: Nous avons procédé à des recherches sur des facteurs pronostiques associés à des résultats défavorables

INTRODUCTION

Older adults (patients ages ≥ 65) are the fastest growing subset of the population in the industrialized world.¹ Although this cohort contains 13% of the population,

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it accounts for 37% of hospital discharges and 43% of patient care days.¹ Although, on average, older adults cost the health care system more than younger cohorts, not every patient over the age of 65 strains these resources similarly.²

Adults sustaining blunt chest trauma represent a specific example of this paradox; although from an epidemiologic perspective, older adults have a higher morbidity and mortality than younger cohorts,³⁻⁵ not every older adult sustaining blunt chest trauma sustains an adverse event. This suggests that risk factors other than age are at play. Indeed, previous systematic reviews on older adults sustaining trauma have suggested that anti-coagulant use, hypotension, increased Injury Severity Score (ISS), and lower Glasgow Coma Score are risk factors for increased mortality.^{6,7}

Prior reviews have examined risk factors for adverse outcomes in older patients sustaining blunt chest trauma.^{5,8,9} To our knowledge, there is only one systematic review in this area, which primarily examined mortality differences between older and younger cohorts⁵ and did not specifically consider patients ages 65 and older as a population (or subpopulation) of interest. Furthermore, prior reviews focused solely on morbidity and mortality and did not investigate other patient-centred outcomes (i.e., quality of life and loss of independence) or health care resource use (i.e., emergency department [ED] recidivism and hospital length of stay [LOS]).^{5,8,9} Thus, the goal of the present study was to systemically review the literature for risk factors related to these broader adverse outcomes in older adults who sustained blunt chest wall trauma.

METHODS

We adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)¹⁰ and the Meta-analysis of Observational Studies in Epidemiology (MOOSE) guidelines in undertaking this review.¹¹

Search strategy

In collaboration with an expert librarian, a search strategy was developed to search EMBASE and MEDLINE (from inception to March 17, 2017). Search terms (medical subject, Emtree headings, and free text words) related to older adults and blunt chest

trauma were used in addition to previously validated geriatric search filters with the goal of being as inclusive as possible (see Appendices 1 and 2).¹² Because adverse events related to chest trauma are diverse, our search strategy was not limited to specific outcomes. In addition, bibliographies of all included studies were screened for potential inclusion in the review. No language restrictions were applied to the initial search strategy, but only abstracts written in English and French were considered for potential inclusion.

Study selection

Search results from EMBASE and MEDLINE were combined using Covidence software (available at www.covidence.org), and duplicates were excluded. Titles and abstracts were independently screened for potential relevance by two reviewers (JS, PD). Our population of interest was patients of age ≥ 65 with blunt chest trauma, which we defined as blunt chest injury resulting in chest wall contusion or rib fractures, with or without immediate life-threatening injury to the lungs or other organ systems. Due to a relatively small number of eligible studies, we elected to include studies that attempted to identify a cohort of older adults sustaining blunt chest trauma, but for logistical reasons had to lower the minimum age for study inclusion. To decrease heterogeneity amongst included studies, studies were only included if the mean age of the study cohort was 65 years or older. Any disagreements were resolved by consensus. If consensus could not be reached, a third reviewer (BT) was consulted to adjudicate. Inter-rater reliability was measured using Cohen's Kappa statistic.

Following the initial screening, a full-text review was performed by two reviewers (JS, PD). Clinical cohort studies were included if there was a longitudinal component investigating the relationship between prognostic factors and an outcome of interest. Studies were excluded if they 1) were a review article, case report, or case-series; 2) were conducted in a study population not meeting inclusion criteria (mean age of group or subgroup ≥ 65 , or patient population not sustaining blunt chest trauma as defined previously); 3) did not analyse risk factors for an outcome of interest; or 4) did not examine an outcome of interest (morbidity, mortality, LOS, ED recidivism, quality of life, or loss of independence).

Outcomes of interest

The primary outcomes of interest were morbidity, mortality, ED recidivism, LOS, quality of life, and loss of independence (defined as discharge to institution). Because morbidity in this patient population was expected to be heterogeneous, we examined any complications reported by study authors, including (but not limited to) pneumonia, intubation, and intensive care unit admission. Mortality was defined as in-hospital or 30-day mortality. Loss of independence implied that the patient was discharged to a higher level of community care than they were admitted from (i.e., transitional care, lodging, or nursing home admittance). ED recidivism was defined as repeat presentation to the ED within 30 days.

Prognostic factors

Prognostic factors for outcomes of interest were classified into three groups for synthesis and to improve clarity of presentation: patient factors, disease factors, and institutional factors. Patient factors included any underlying features, conditions, or demographic characteristics, which were present before the acute injury (e.g., patient age, sex, co-morbidities). Disease factors included any risk factors related to the traumatic event (e.g., multiple rib fractures, flail chest, associated trauma, mechanism of injury). Institutional factors included elements related to the ED admission/hospital admission (e.g., treatment by trauma team, treatment by multi-disciplinary team, adverse events).

Critical appraisal of included studies

Risk of bias (ROB) was assessed by two reviewers (JS, PD), using the Quality in Prognostic Studies (QUIPS) tool.¹³ The QUIPS tool examines ROB in six domains: study participation, study attrition, prognostic factor measurement, outcome measurement, study confounding, and statistical analysis and presentation. Inter-rater reliability was assessed using the Cohen's Kappa statistic.

Data extraction

Data extraction was performed by two independent reviewers (JS, PD), using a piloted data extraction form. Where disagreement occurred, the paper was reviewed and the discrepant variable/value was clarified. Extracted information included study characteristics (i.e., type of

study, number of patients, outcomes of interest), patient characteristics (i.e., age, sex, co-morbidities, ISS), and strength of association (i.e., odds ratios [OR] and relative risks) between prognostic factors and outcomes of interest. If relevant information was unclear or missing, up to three attempts were made to contact the primary author via email to obtain the pertinent information.

Data synthesis

We used descriptive statistics (means and percentages) to assess study characteristics and the reporting of risk factors. Because a meta-analysis was not performed, mean morbidity and mortality were calculated using a non-weighted average of reported means. Where appropriate, and when not reported, univariate OR and 95% confidence intervals were calculated by creating 2 × 2 contingency tables using MedCalc software. Data synthesis and meta-analysis of three or more studies examining the same predictor of an adverse outcome were planned using RevMan 5.3 software. Unfortunately, due to the paucity of studies satisfying selection criteria, as well as heterogeneity in how risk factors were measured, this was not possible.

RESULTS

Our initial search strategy produced 894 citations in EMBASE and 1,497 citations in MEDLINE (Figure 1). After excluding duplicates, a total of 2,297 studies underwent initial title and abstract screening; 187 studies were subjected to a full-text review. Thirteen studies met all eligibility criteria and were included in the final review. Overall, agreement on study inclusion was very good ($k = 0.790$).

Study characteristics

Table 1 summarizes the characteristics of the 13 included studies representing a total of 79,313 patients.¹⁴⁻²⁶ Studies were published between 1985 and 2016; 11 studies were performed in the United States,^{14-17,20-26} 1 was performed in Egypt,¹⁹ and 1 was performed in Israel.¹⁸ All 13 were retrospective cohort studies, with the majority using data from trauma registries. Study populations ranged in size from 38 to 67,659 patients. Overall mortality across studies was 8.4%, and the overall complication rate was 26.5%. Six studies included mortality as a primary outcome

of interest.^{17-19,21,25,26} Eight studies included morbidity as a primary outcome of interest.^{14-16,18-20,22,23} Six studies examined prognostic factors related to LOS.^{14-16,22,24-26} One study examined prognostic factors related to discharge to an extended care facility.¹⁶ None of the studies explored risk factors for ED recidivism or patient quality of life.

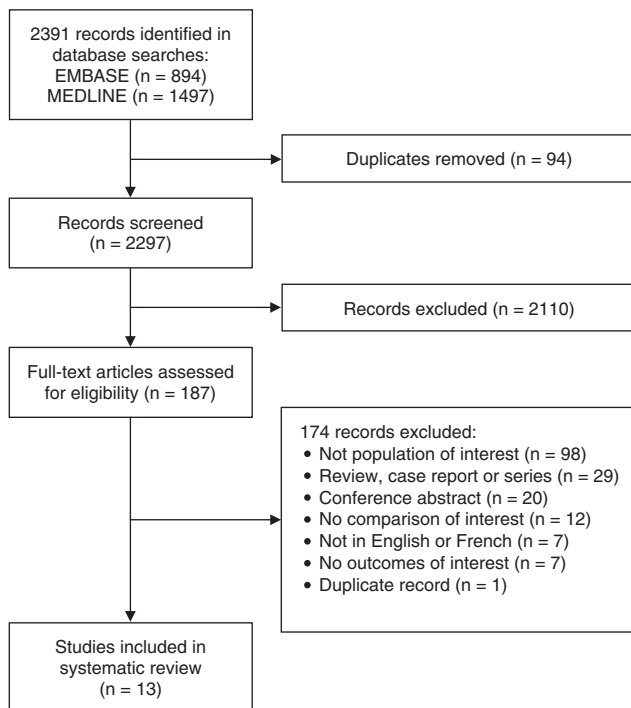


Figure 1. Selection of articles for inclusion.

Quality assessment of included studies

Table 2 summarizes the ROB assessment for all included studies. Overall inter-rater agreement was excellent ($k = 0.803$). Most studies were of low to moderate quality and at moderate to high ROB. The main issues with study quality were related to prognostic factor measurement, outcome measurement, study confounding, and statistical analysis. Nine studies were found to have moderate to high ROB due to incomplete reporting on how prognostic factors were measured.^{14-19,22,24,25} Most studies were judged to have high ROB based on partial reporting of confounder measurements. Seven studies were of moderate to high ROB in relation to outcome measurement.^{14-16,19,20,24,25}

Prognostic factors associated with post-injury mortality

Prognostic factors associated with post-injury mortality are shown in Table 3. Three studies examined associations between patient factors and mortality. One study found an association between a history of congestive heart failure and mortality after adjusting for age, ISS, the need for intubation, and trauma centre volume.²¹ One study found a univariate association between ages ≥ 80 and mortality,¹⁷ whereas two others found a multivariate association between advanced age and mortality.^{21,26} The association between disease factors and mortality was examined in five studies. Univariate associations were reported for increasing

Table 1. Study and patient characteristics

Study	Location	N	Age cut-off	Trauma type	Mean ISS	Mean LOS	% Mortality	% Morbidity
Alexander 2000 ¹⁴	USA, L2TC	62	≥ 65	Isolated rib fractures (≥ 2)	NR	6.4	4.8*	33.9*
Allen 1985 ¹⁵	USA, L1TCs & L2TCs	48	≥ 60	Blunt chest trauma	18.0	16.6*	2.1*	20.1*
Bakhos 2006 ¹⁶	USA, L2TC	38	≥ 65	Rib fractures	6.9	4.5	2.6*	10.5*
Bansal 2011 ¹⁷	USA, CIREN centres	287	≥ 65	Rib and sternal fractures	NR	NR	32.8*	NR
Barnea 2002 ¹⁸	Israel, TCC	77	≥ 65	Isolated rib #s	NR	4.5	8.0	38.0
Elmistekawy 2007 ¹⁹	Egypt, TCC	39	≥ 60	Isolated rib #s	NR	7.6	10.3*	35.9
Gonzalez 2015 ²⁰	USA, L1TCs	400	≥ 55	Rib fractures	15.0*	NR	3.3	17.5
Harrington 2010 ²¹	USA, L1TCs and L2TCs	1,621	≥ 50	Rib fractures	11.7	NR	4.6*	NR
Kieninger 2005 ²²	USA, L1TCs	187	≥ 55	Rib fractures	8.9*	6.5*	2.6	51.0
Lotfipour 2009 ²³	USA, L1TC	99	≥ 65	Isolated blunt chest trauma	10.6	7.4	2.0	16.0
Sahr 2013 ²⁴	USA, L1TC	148	≥ 65	Rib fractures	15.3*	7.7*	9.5	NR
Shulzhenko 2016 ²⁶	USA, L1TCs & L1TCs	67,659	≥ 65	Rib fracture	14.4	7.9	7.0	15.6
Stawicki 2004 ²⁵	USA, L1TC	8,648	≥ 65	Rib fractures	19.4	13.1	20.1	NR

ISS = Injury Severity Score; L1TC = Level I trauma centre; L2TC = Level II trauma centre; LOS = length of stay; NR = not reported; TCC = tertiary care centre.
*Calculated value.

Table 2. Risk of bias assessment using the Quality in Prognostic Studies tool

Study	Study participation	Study attrition	Prognostic factor measurement	Outcome measurement	Study confounding	Statistical analysis and presentation
Alexander 2000	Low	Low	Moderate	High	High	High
Allen 1985	Low	Low	High	Moderate	High	High
Bakhos 2006	High	Low	Moderate	Moderate	High	High
Bansal 2011	Low	Low	High	Low	High	High
Barnea 2002	Moderate	Low	Moderate	Low	Low	Moderate
Elmistekawy 2007	Moderate	Low	High	High	Moderate	Moderate
Gonzalez 2015	Low	Low	Low	Moderate	Moderate	Low
Harrington 2010	Low	Low	Low	Low	Low	Low
Kieninger 2005	Low	Low	High	High	High	High
Lotfipour 2009	Low	Low	Low	Low	High	High
Sahr 2013	Low	Low	Moderate	Low	High	High
Shulzhenko 2016	Low	Low	Low	Low	Low	Low
Stawicki 2004	Low	Low	Moderate	Moderate	High	High

Table 3. Prognostic factors associated with post-injury mortality

Category	Study	Variable	Association*
Patient	Bansal 2011	Age \geq 80	2.37 (1.38-4.07; $p = 0.0018$)
	Harrington 2010	Age	1148.5 (184.9-7132.6; $p < 0.001$)
		History of CHF	5.7 (1.3-25.0; $p = 0.02$)
Disease	Shulzhenko 2016	Age (per 1 yr increase)	1.059 (1.054-1.064; $p < 0.05$)
	Barnea 2002	No. of rib fractures	$p = 0.006^{\dagger}$
	Elmistekawy 2007	Pneumonia	83.6 (3.7-1898.1; $p = 0.006^{\dagger}$)
	Harrington 2010	ISS	43.9 (4.3-452.8; $p = 0.001$)
		Need for intubation	23.3 (11.9-45.2; $p < 0.001$)
	Stawicki 2004	No. of rib fractures	$p = 0.001^{\dagger}$
Institutional	Shulzhenko 2016	>8 rib fractures	1.54 (1.42-1.68; $p < 0.001$)
	Harrington 2010	Admission to L1TC	4.5 (1.4-14.8; $p = 0.01$)

CHF = congestive heart failure; ISS = Injury Severity Score; L1TC = Level I trauma centre.
*Data are presented as odds ratios with 95% confidence intervals and p values (if available).
[†]Univariate association using chi-square test was reported.
[‡]Calculated odds ratio and 95% confidence interval.

number of ribs fractured^{18,25} and development of pneumonia,¹⁹ whereas multivariate associations were reported for higher ISS,²¹ need for intubation,²¹ and having eight or more fractured ribs.²⁶ Only one study reported an association between mortality and an institutional factor. The authors reported a higher mortality in patients admitted to a Level I trauma centre after adjusting for age, ISS, need for intubation, and pre-existing congestive heart failure.²¹ Although three studies examined age^{17,21,26} and rib fractures^{18,25,26} as risks for mortality, meta-analysis was felt to be inappropriate due to heterogeneity in how these variables were measured.

Prognostic factors associated with post-injury morbidity

Patient, disease, and institutional factors associated with post-injury morbidity are summarized in Table 4. Six patient factors were investigated across studies. Univariate associations were reported for the presence of cardiopulmonary disease¹⁴ and diabetes mellitus,^{18,19} whereas multivariate associations were reported for age,²⁶ chronic obstructive pulmonary disease (COPD),²⁰ protein calorie malnutrition,²⁰ and ambulatory assist devices.²⁰

There were six disease factors associated with post-injury morbidity examined across included studies.

Table 4. Prognostic factors associated with post-injury morbidity

Category	Study	Outcome	Variable	Association*
Patient	Alexander 2000	Myocardial infarction, pneumonia, pulmonary contusion, or pleural effusion	Presence of CD	8.2 (2.3-29.1; $p = 0.001$) [†]
	Barnea 2002	Pulmonary complication	Presence of diabetes mellitus	5.7 (1.4-23.7; $p = 0.02$) [†]
	Elmistekawy 2007	Pulmonary contusion or pneumonia	Presence of diabetes mellitus	11.5 (1.9-68.5; $p = 0.007$) [†]
	Gonzalez 2015	Intubation or pneumonia	COPD	3.92 (1.65-9.32; $p = 0.002$)
			Protein calorie malnutrition	2.97 (1.56-5.64; $p < 0.001$)
Ambulatory assist device			2.9 (1.04-8.92; $p = 0.042$)	
Shulzhenko 2016	Need for MV Pneumonia	Age (per 1 yr increase)	1.004 (1.001-1.007; $p < 0.05$)	
		Age (per 1 yr increase)	1.007 (1.002-1.012; $p < 0.05$)	
Disease	Allen 1985	Pneumonia or pulmonary embolus	Need for early MV	7.8 (1.4-43.8; $p = 0.02$) [†]
	Barnea 2002	Pulmonary complication	Lower oxygen saturation at admission	$p = 0.002$ [‡]
			No. of rib fractures	$p = 0.027$ [§]
	Elmistekawy 2007	Pulmonary contusion or pneumonia	No. of rib fractures	$p = 0.012$ [§]
	Gonzalez 2015	Intubation or pneumonia	Need for tube thoracostomy	2.36 (1.21-4.6; $p = 0.011$)
			Per 1 point increase in ISS	1.09 (1.05-1.14; $p < 0.001$)
			Per 1 increase in no. of rib fractures	1.13 (1.01-1.27; $p = 0.039$)
	Shulzhenko 2016	Need for MV Pneumonia	>8 rib fractures	1.54 (1.42-1.68; $p < 0.001$)
>8 rib fractures			1.65 (1.46-1.87; $p < 0.001$)	
Institutional	Kieninger 2005	Pleural effusion or pneumonia	Use of epidural over IV analgesia	3.3 (1.7-6.6; $p = 0.0006$) [†]

CD = cardiopulmonary disease; COPD = chronic obstructive pulmonary disease; ISS = Injury Severity Score; IV = intravenous; MV = mechanical ventilation; OR = odds ratio.
*Data are presented as odds ratios with 95% confidence intervals and p values (if available).
[†]Calculated odds ratio and 95% confidence interval.
[‡]Univariate association using student's t -test was reported.
[§]Univariate association using chi-square test was reported.

Univariate associations were reported for the need for early mechanical ventilation,¹⁵ oxygen saturation,¹⁸ and number of rib fractures,^{18,19} whereas multivariate associations were reported for the need of tube thoracostomy,²⁰ increasing ISS,²⁰ per one increase in number of ribs fractured,²⁰ or having eight or more ribs fractured.²⁶

Only one institutional factor was investigated in relation to post-injury morbidity. The authors reported higher morbidity in patients receiving epidural rather than intravenous (IV) analgesia after adjusting for ISS and the presence of pre-existing cardiopulmonary disease.²² Although three studies examined rib fractures as a risk factor for pneumonia, meta-analysis was felt to be inappropriate due to heterogeneity in how the risk factor and outcome variable were measured.^{19,20,26}

Prognostic factors associated with length of stay

The patient, disease, and institutional factors associated with LOS are summarized in Table 5. A total of three patient factors were investigated across studies, suggesting univariate associations between in-hospital LOS and the presence of cardiopulmonary disease,¹⁴ vital capacity,¹⁶ and percentage of predicted vital capacity.¹⁶

Two disease factors were investigated across studies, and reported associations included the number of ribs fractured (univariate),^{16,25} having 5 or more ribs fractured (multivariate, adjusting for 23 patient and hospital factors),²⁶ and the need for mechanical ventilation (univariate).¹⁵

There were two institutional factors analysed across studies. Kieninger et al. reported increased LOS in patients receiving epidural rather than IV analgesia

Table 5. Prognostic factors associated with hospital length of stay (LOS)

Category	Study	Variable	Association*
Patient	Alexander 2000	Presence of CD	8.5 v. 4.3 days ($p < 0.05$)
	Bakhos 2006	Vital capacity	$p = 0.0076^\dagger$
Disease		% of predicted vital capacity	$p = 0.0172^\dagger$
	Allen 1985	Need for mechanical ventilation	38 v. 13 days ($p < 0.05$)
	Bakhos 2006	No. of rib fractures	$p = 0.01^\ddagger$
	Stawicki 2004	No. of rib fractures	$p = 0.001^\ddagger$
Institutional	Shulzhenko 2016	>5 rib fractures	$p < 0.001^\ddagger$
	Kieninger 2005	Use of IV v. epidural analgesia	5.6 v. 8.6 days ($p = 0.0065$)
	Sahr 2013	Protocolized care of rib fracture patients v. pre-protocol care	7.1 v. 8.2 days ($p = 0.006$) [‡]

CD = cardiopulmonary disease; IV = intravenous.
 *Data are presented as mean LOS and p values (if available).
 † p -values from linear regression analysis were reported.
 ‡ p -values from analysis of variance analysis were reported.

after adjusting for ISS and pre-existing cardiopulmonary disease,²² whereas Sahr et al. reported an unadjusted decreased LOS in rib fracture patients receiving protocolized care.²⁴

Prognostic factors associated with discharge to an institution

Only one study examined the association between prognostic factors and discharge to an institution.¹⁶ This study showed that patients discharged to an extended care facility had lower mean vital capacities (within 48 hours of admission) than those discharged to home (0.9 ± 0.4 L v. 1.3 ± 0.5 L; $p = 0.025$).

DISCUSSION

As the population continues to age, the care of geriatric patients is receiving more attention as older adults have proportionally higher rates of adverse events than younger cohorts.^{3,27} Older adults may differ from other patients in a variety of ways, including the number of (and severity of) co-morbid conditions, post-injury problems that can arise, and the extent of treatment offered to them. Further, the fast-paced, goal-oriented environment of the ED is not always conducive to the treatment of older patients who often have more acute, complex, or atypical presentations of illness,²⁸ highlighting a need for behavioural or system change.

This is the first systematic review to specifically examine risk factors for adverse outcomes among older adults with blunt chest wall trauma. We identified

13 studies, which reported on 26 risk factors for adverse outcome in older adults sustaining blunt chest trauma. There was significant variation in risk factor and outcome measurement across studies, and, with the exception of age and rib fractures reported, associations were limited to one or two studies. Therefore, a meta-analysis could not be performed. Of note, most studies focused on finding novel associations using small datasets rather than building on previous research. Indeed, only six of the included studies used multivariate analysis techniques, potentially inflating the relative strength of associations because confounders were not controlled for.^{18-22,26} Lastly, all included studies used phase one (identifying associations) methodology,²⁹ and only one study considered the potential for prognostication.²³

A previous systematic review examining risk factors for mortality in blunt chest trauma patients ages ≥ 18 suggested that ages >65 , three or more rib fractures, pre-existing cardiopulmonary disease, as well as the development of pneumonia were associated with mortality.⁵ Our study suggests that, in older adults, additional disease factors may be at play, including higher ISS and the need for intubation. While these outcomes are unlikely to be modifiable, they may be potentially useful in prognostic models as well as in guiding goals of care. Of interest, Harrington et al. reported that patients admitted to Level I trauma centres tended to have higher mortality rates than those admitted to Level II trauma centres on a multivariate analysis.²¹ This suggests a need for further research because unmeasured markers of trauma burden are likely to be at play.²¹

Earlier reviews have suggested that an increasing number of rib fractures are associated with pulmonary

complications in patients sustaining blunt chest wall trauma.^{8,9} Our review is the first to systematically examine risk factors for morbidity in older adults sustaining chest trauma and identify 10 potential patient and disease factors for morbidity. Again, none of these are likely to be modifiable; but, with additional study, they could be incorporated into prognostic models to help guide care. Of note, Kieninger et al. reported an increase in complication rate associated with the use of epidural over IV analgesia²² and noted that this association persisted when ISS and cardiopulmonary co-morbidities were accounted for. The study was retrospective with the choice of analgesia left up to the care team, and it is possible that unmeasured markers of trauma burden were apparent to the care team but could not be measured. However, it does highlight that institutional factors can affect patient outcome; further study in this area is warranted.

As the population ages, the rising demand on the health care system is becoming increasingly concerning. One of the current rate limiters in emergency care is inpatient LOS because it has a trickle-down effect on ED flow.³⁰ Although pre-existing conditions and markers of trauma burden are unlikely to be modified, two studies suggested potential modifiable risk factors that could improve patient care and contribute to decreased LOS.^{22,24} Due to the retrospective design of the Kieninger et al. study, it is difficult to judge the impact of IV over epidural analgesia on LOS; but promisingly, Sahr et al. showed that the use of a protocolized care plan in patients over age 65 can reduce LOS.²⁴ Further study is needed to assess the external validity of these findings, as well as their potential impact on health care costs.

Only one study assessed prognostic factors associated with loss of independence, and no studies examined quality of life or ED recidivism, identifying an important gap in the literature. Given that many older patients consider quality of life to be more valuable than duration of life,^{31,32} additional research is needed to investigate patient-centred outcomes related to quality of life such as ED recidivism and discharge to a continuing care institution.

This study had several limitations. Firstly, all systematic reviews are limited by the inclusiveness of their search strategy. To minimize the potential for missing studies of interest, we used an expert librarian to develop our search strategy and attempted to make it as

sensitive as possible. Further, we hand-searched the references of included studies to minimize the chance that an important study was missed. Secondly, we were limited by the quality of included studies. Over half of the included studies did not include a multivariate analysis, making it difficult to interpret the relative strength of associations across studies. Thirdly, five studies did not specifically examine patients ages 65 years and older, and the inclusion of younger patients in the study cohorts has the potential to weaken the strength of associations. We opted to include these studies for two reasons: 1) historically, the definition of older adults has changed over time, and there may have been a good reason to study a slightly younger cohort at the time of the initial study; and 2) due to the relatively small number of included studies, we felt it was important to highlight the findings of prior researchers to aid future research in this area.

A fourth limitation of the current study was the significant heterogeneity in the trauma burden of patients among included studies. The mean ISS of included studies ranged significantly (from 6.9 to 19.4). Further, four studies did not report ISS, and several studies did not adjust for injury severity. Lastly, the definition of morbidity varied across studies, making it difficult to assess the severity of complications. For example, complications such as pleural effusion, pneumonia, and intubation were not necessarily reported separately. This highlights the need for clearer definitions of complication severity in future studies.

CONCLUSION

Our findings indicate that there is limited high-quality evidence available in the literature on risk factors for adverse outcomes in elderly patients with blunt chest wall trauma. Currently, there are no established models that can help in predicting adverse outcomes in this specific group. Given the aging population and the likely future increase in ED presentations of older aged patients, additional high quality studies are indicated.

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SUPPLEMENTARY MATERIAL

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