CE

Long-term Outcomes After Blunt Injury to the Boney Thorax

An Integrative Literature Review

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ABSTRACT

Management of blunt injury to the boney thorax centers on the hospital; yet, these injuries continue to impact patients long after hospitalization. The purpose of this literature review was to identify long-term outcomes associated with this injury. A literature search found 616 studies and, after screening, yielded 6 articles for review. Patient and injury characteristics and postinjury assessment findings were explored. The impact of this injury can be prolonged and life altering, prompting the need for further investigation. A greater understanding of injury-specific posthospitalization outcomes could elucidate the impact of these injuries on patients, families, and society.

Key Words

Blunt injury, Boney thorax, Outcomes, Posthospitalization, Rib fracture

Blunt injuries to the boney thorax account for 25% of all trauma-related deaths, therefore contributing to traumatic injury's rank as the leading cause of death, disability, and years of lost life.[1,2] The magnitude of the morbidity associated with nonfatal and disabling injuries can be devastating, with physical, psychological, and social implications.[3] The resulting burden can profoundly impact patient recovery and return to productivity. The consequence of these ongoing issues is far reaching and may entail significant social and economic costs, for the individual, family, and community[4]; however, the degree of long-term morbidity associated with blunt injuries to the boney thorax remains unclear.

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Blunt injuries to the boney thorax may present as isolated rib fractures, rib fractures with extrathoracic injuries, flail chest, or sternal fracture. Most often, these injuries are related to motor vehicle crashes; however, blunt chest injuries may also be as a result of a fall from a height, work accidents, assaults, and recreation-related injuries. The severe pain associated with these injuries limits adequate pulmonary hygiene, resulting in sputum retention, atelectasis, and reduced functional residual capacity, which has the potential to be more debilitating and harmful than the injury itself.[5,6]

Traditionally, care practices have focused on expedient diagnosis and management of injuries, establishing physiological stability, and the prevention/management of complications.[7] Efforts to assess this care have been limited to the evaluation of morbidity and mortality rates in addition to length of stay in hospital.[8] Very little is known about patient experiences related specifically to their injuries after discharge from the hospital, as evidenced by the paucity of this literature.

The ultimate goal of trauma care is to restore the injured patients to their former functional status.[9] The development of trauma systems and an expanding body of scientific knowledge have contributed to improved survival rates for patients with multiple injuries regardless of age.[10] However, to achieve this, further understanding the patient experience beyond the acute hospitalization becomes critical. This will not only expand the collective body of knowledge but also evaluate the quality of care rendered.

PURPOSE

The purpose of this integrative review was to synthesize the current state of the science related to the long-term outcomes associated with blunt injuries to the boney thorax. The questions guiding this review include the following: (1) How do patient characteristics (age and preinjury health), injury characteristics (type and injury severity), and postinjury assessment findings (pain, chest deformity, pulmonary function, complications, and employment status) impact patient outcomes after a blunt injury to the boney thorax? and (2) What conclusions can be drawn to inform future research to maximize patient functional

status earlier in the recovery trajectory after sustaining blunt injury to the boney thorax?

METHODS

The integrative review methodology as outlined by Whittemore and Knafl[11] was used. This methodology focuses on the identification of the problem of interest, examination of the literature, systematic evaluation of the data, analysis of data, and reporting results.[11] The review of the existing literature allows varied perspectives related to the issue of long-term patient outcomes after blunt injury to the boney thorax.

Studies for this integrative review were identified by searching computerized databases, including MEDLINE, Cumulative Index to Nursing and Allied Health, PubMed, and Scopus. Medical Subject Headings terms were used as follows: wounds and injuries, thoracic injuries, flail chest, lung injury, and rib fractures. In addition, the reference lists of identified articles were reviewed for additional important literature. Inclusion criteria were (1) studies published in English, (2) studies published between 1982 and June 2012, (3) studies from peer-reviewed journals, (4) studies with samples that included persons aged 15 years and older, and (5) studies associated with nonpenetrating mechanism of injury. The broad 30-year time frame was used to fully explore the literature because of the limited availability of resources and no previous review had been conducted. Exclusion criteria were (1) studies associated with closed head injuries and spinal cord injuries, (2) unpublished manuscripts, and (3) studies involving outcomes of acute hospitalization.

As shown in Figure 1, the search yielded 616 articles. Initial screening by title and type (eg, case report, review, and population) resulted in the exclusion of 482 articles. The remaining 134 articles were obtained in full text for further assessment of relevance. The article abstracts were reviewed, with 54 articles being excluded. The remaining 80 articles were reviewed in full and resulted in the exclusion of 74 more articles, thereby bringing the final yield to 6 articles, as listed in Table 1.

Of the articles outlined in Table 1, 2 were prospective, single-center, cohort studies[12,13]; one was a prospective, multicenter, cohort study[14]; and the remaining were retrospective, single-center, descriptive studies.[15-17] In 4 of the studies, the evaluations were obtained during a single posthospitalization assessment, 50 days to 12 years after injury,[12,15-17] whereas the remaining 2 studies evaluated patients through a series of 4 assessments in the days to months after injury.[13,14] In 5 studies, the sample sizes were small, ranging from 20 to 46 persons; of those, 4 studies had issues with patient retention, leaving a range of 14 to 32 total patients available for interpretation.[12,13,15-17] Chauny et al[14] included several centers, which yielded 1057 subjects in that study.

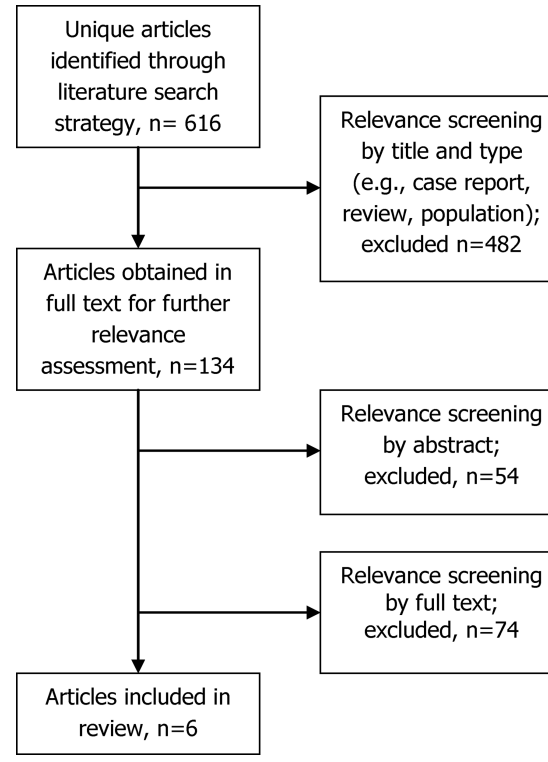

Figure 1. Flow chart of article selection process.

Data Evaluation

Because of the diverse representation of the primary sources, reports were recorded with a 3-point scale (high, moderate, or low) according to 2 criteria: (1) methodological rigor and (2) data relevance. The methodological review included an evaluation of the research design, plan for observing or measuring variables, sample selection and representativeness, ethical integrity, and reliability and validity.[18] The evaluation of data relevance incorporated the studies' contribution to changes in policy or practice, impact on patient health outcomes, and identification of gaps for further investigation.[19] No article was excluded as a result of the data evaluation rating; however, the score was used in the data analysis phase.

Data Analysis

Data were extracted from primary sources on sample characteristics and methods related to posthospitalization, long-term outcomes after blunt injury to the boney thorax. The categories of data extracted included patient characteristics, injury characteristics, and assessment aspects after injury. Table 1 displays coded data by category to facilitate evaluation and comparisons. As data were synthesized, each primary source was reviewed to ensure that the current interpretations remained congruent with the original source.

TABLE 1 Literature Overview

Reference	Purpose	Method	Time of Postacute Assessment	n	Outcome Measures	Coding: Methodological Rigor	Coding: Data Relevance
Beal and Oreskovich[12]	To determine the long-term disability associated with flail chest	Prospective, single-center cohort study	Single assessment between 50 and 732 d (~2 y)	20 14 followed long-term	Chest wall pain Chest wall deformity Exertional dyspnea Employment status General health Complication	++	++
Chauny et al[14]	To quantify incidence and identify risk factors associated with development of pneumonia after minor thoracic trauma in outpatients	Prospective, multicenter cohort study	Assessments at 1, 2, 4, and 12 wk	1057	Pneumonia incidence	++	+
Kerr-Valentic et al[13]	To determine the baseline disability associated with rib fractures	Prospective, single-center cohort study	Assessments at 1, 5, 30, and 210 d (~7 mo)	40 **Follow-up** at 30 d (33 patients 80%) at 120 d (29 patients 73%)	Rib fracture pain Body pain[a] Pain-medication use Total days lost from work/ usual activity General health[a] Social functioning[a] Mental health[a] Role limitations[a]	+++	+++
Landercasper et al[15]	To determine the late effects for patient after sustaining traumatic rib fracture (flail)	Prospective, single-center study	Single assessment between 6 mo and 12 y (mean 5 y)	37 21 examination 32 survey	Dyspnea Chest pain/ tightness Smoking history Employment history Lifestyle changes Chest x-ray Chest expansion Spirometric measures (FVC, FEV1, and MVV) Carbon monoxide diffusion analysis	++	++

(*continues*)

TABLE 1 Literature Overview (*Continued*)

Reference	Purpose	Method	Time of Postacute Assessment	n	Outcome Measures	Coding: Methodological Rigor	Coding: Data Relevance
Mayberry et al[16]	To evaluate the long-term outcomes after severe chest wall injuries	Prospective, single-center study	Single assessment between 19 mo and 8 y	46	Pain[a]/mental health[a] Disability/role limitations[a] Employment Functional status (physical/social) Overall health/general perception[a] Preinjury and current daily activity level Energy-fatigue[a] Preinjury medical comorbidities Significant health changes after injury Complications	++	+++
Mouton et al[17]	To evaluate the long-term outcome of patients with flail chest	Prospective, single-center study	Single assessment between 6 mo and 12 y	23	Chest wall and shoulder girdle function Working capacity Sport activities Pain Chest wall deformity Morbidity	++	++

Abbreviations: FVC, forced vital capacity; FEV_1, FEV in the first second of expiration; MVV, maximum voluntary ventilation.

[a]*Components of 36-Item Short Form Health Survey; coding: +, low; ++, moderate; +++, high.*

FINDINGS

Patient Characteristics

Age

Age was reported in all 6 studies as part of the demographic data; however, only 2 studies included age as a component of posthospitalization outcome after blunt injury to the boney thorax.[14,15] The demographic data revealed ages ranging from 7 to 100 years; however, the mean ages were generally reported near 50 (range, 38-53).[12-17] The 2 studies reporting age-associated outcomes provided dissimilar experiences.[14,15] For patients with minor injuries treated as an outpatient, age was found not to be a risk factor associated with delayed onset of pneumonia.[14] Whereas, Landercasper et al[15] found that in patients younger than 65 years, mortality rate was 7% compared with a mortality rate of 29% in those older than 65 years.

Preinjury Health

When measuring outcomes related to blunt injury to the boney thorax, it can be beneficial in understanding the impact of injury to measure a patient's preinjury health. This can be assessed in various ways, including assessment of smoking history, baseline physical health, and ability to work. Of the 6 studies, smoking was reported in only 1 study, in which 46% of the patients smoked.[15] Mayberry et al[16] provided the only evaluation of preinjury activity status and health. In this study, 15 patients with severe chest wall

injuries were evaluated for preinjury and current (postinjury) level of physical activity. Self-reported activity was assessed on a 4-point scale ranging from 1 (vigorous activity) to 4 (sedentary).[16] There was a significantly lower level of physical activity postinjury than preinjury ($P = .02$).[16] This study also included comorbidities as part of the preinjury health assessment and reported that 47% (n = 7) of patients had preinjury medical conditions such as hypertension (n = 5), cardiac disease (n = 2), and depression (n = 1) with one patient having more than one preinjury condition.[16] However, the impact on long-term outcomes remains unclear and was not analyzed according to preinjury health status. With respect to ability to work, only 1 study reported employment status and found 88% (n = 32) of patients employed at the time of injury.[15]

Injury Characteristics

Blunt injuries to the boney thorax are commonly described by type and severity of injury (Table 2). Of the 6 studies, 2 involved patients with flail chest,[12,15] 3 involved patients with varying numbers of rib fractures.[13,14,16] The remaining study included patients with sternal fracture and those with and without extrathoracic injury.[17]

The number of fractures of the boney thorax can offer insight into the severity of a patient's injury and is often reflected through the Injury Severity Score (ISS), as described in 2 of the 6 studies reviewed.[12,16] The type or severity of injury was not specifically addressed in the analysis of the 4 remaining studies. The ISS serves as a standard by providing an overall score from 0 to 75 for patients with multiple injuries.[20] The ISS correlates with mortality rate, morbidity, length of stay, and other measures of severity.[20]

Beal and Oreskovich[12] evaluated patients with and without extrathoracic injury. As would be expected, patients without extrathoracic injury had a lower ISS (mean 20.75), although they reported an average of 9.3 (range, 4-15) fractures, than those with extrathoracic injury who had a mean ISS of 33, with an average of 7.5 (range, 1-16) fractures.[12] Mayberry et al[16] studied 40 patients, of which 82% (n = 33) had associated injuries with a mean ISS of 30 ± 12. Considerations for the severity of injury not only to the boney thorax but also to the underlying lung parenchyma are important when discussing outcomes; however, no study reported this data.

Assessment Aspects

Assessment outcomes posthospitalization with blunt injury to the boney thorax have been measured using a number of variables. The variables addressed through this review are illustrated in Table 3 and include outcomes such as pain, pulmonary function, employment status, physical functioning, chest wall deformity, and complications.

TABLE 2 Injury-Related Characteristics Summary

Reference	Injury Characteristics	Boney Fractures of the Thorax	Injury Severity Score
Beal and Oreskovich[12]	No extrathoracic injury	Mean 9.3 (range, 4-15) (sternal fracture)	Mean 20.75
	Extrathoracic injury	Mean 7.5 (range, 1-16)	Mean 33
Chauny et al[14]	Minor chest injury (details not reported)	Not reported	Not reported
Kerr-Valentic et al[13]	No extrathoracic injury (23; 57.5%)	≤2 rib fractures (18; 45%)	Not reported
	Extrathoracic injury (17; 42.5%)	≥3 rib fractures (22; 55%)	
Landercasper et al[15]	Flail chest	Not reported (by definition, at least 2 consecutive ribs in ≥2 places)	Not reported (at least 9 to 25)
Mayberry et al[16]	No extrathoracic injury (7; 17.5%)	Not reported	Mean 30 ± 12
	Extrathoracic injury (33; 82.5%)		
Mouton et al[17]	Flail chest	Not reported (by definition at least 2 consecutive ribs in ≥2 places)	Not reported (at least 9 to 25)

TABLE 3 Postinjury Patient Assessment Variables

Reference	Pain	Pulmonary Function	Employment	Physical Function	Chest Wall Deformity	Mental/Social Health	Complication
Beal and Oreskovich[12]	+	+	+	−	+	−	+
Chauny et al[14]	−	−	−	−	−	−	+
Kerr-Valentic et al[13]	+	−	+	−	−	+	−
Landercasper et al[15]	+	+	+	+	+	−	−
Mayberry et al[16]	+	−	+	+	−	−	+
Mouton et al[17]	+	−	+	+	+	−	+

"+" indicates concept included in study; "−" indicates concept not included in study.

Pain

Pain was a consistent outcome measured in 5 of the 6 studies.[12,13,15-17] General reports of prolonged pain were described in 3 studies, with frequencies of 36% (n = 5), 49% (n = 15), and 24% (n = 5) of patients, respectively.[12,15,17] Interestingly, only 2 studies reported measurements quantifying the patients' pain experience. Kerr-Valentic et al[13] measured pain by using a 10-point scale, with 10 representing worst pain, and found patient pain levels at 120 days posthospitalization (1.0 ± 1.4) were less intense and variable than at 30 days (3.5 ± 2.1). Mayberry et al[16] used the McGill Pain Questionnaire-Pain Rating Index as a method of measuring the sensory, affective, and subjective experiences associated with pain.[21] They found that long-term mean score of McGill Pain Questionnaire-Pain Rating Index for blunt thoracic injury patients was 6.7 ± 2.1, where a score of 16 is commonly associated with musculoskeletal sprains.[16]

Pulmonary Status

The primary clinical focus for patients with blunt injury to the boney thorax remains optimization of pulmonary status as a method of reducing complications. Two of the 6 studies assessed pulmonary status through reports of exertional dyspnea, smoking history, and changes in lung volumes, spirometry, and radiological studies.[12,15] Exertional dyspnea was described in 2 studies, with one study reporting as much as 63% (n = 20) of patients experiencing exertional dyspnea[15] compared with 29% (n = 4) of patients in the other study.[12] In addition, one study found self-reported smoking decreased 75% from the pre- to postinjury period.[15] Landercasper et al[15] noted that patients with blunt injury to the boney thorax exhibited decreased lung volumes (27%; n = 7), abnormal spirometry measurements (57%; n = 12), and radiological changes (100%; n = 26). Interestingly, the Landercasper et al[15] study also found greater exertional dyspnea along with a large decrease in smoking. Unfortunately, the question remains as to whether dyspnea impacts decreased smoking because correlations were not sought.

Chest Wall Deformity

A structural defect of the boney thorax can contribute to patient complaints of pain and their ability to conduct pulmonary hygiene maneuvers, therefore increasing the risk of complications. Of the studies reviewed, 3 addressed the frequency of chest wall deformity, with Beal and Oreskovich[12] reporting 21.4% (n = 3) and Landercasper et al[15] reporting 26.9% (n = 7). Whereas, the third study by Mouton et al[17] found that patients after rib fixation did not report any chest wall deformity since the deformity was corrected operatively. This coincides with the rates for exertional dyspnea and decreased lung volumes as noted earlier.[12,15]

Physical Function

Physical functioning was reported in 4 studies using self-report methodologies.[13,15-17] Of these, 2 studies used portions of the 36-Item Short Form Health Survey as a measurement tool[13,16]; however the components of the 36-Item Short Form Health Survey were not explicitly reported. In addition, Landercasper et al[15] found that approximately 72% (n = 23) of patients reported a slight change in overall physical activity compared with the findings by Mayberry et al[16] where they found patients reported minor changes (63% [n = 17]) and notable decline in functional status (37% [n = 10]) after blunt injury to the boney thorax. In contrast, Mouton et al[17] found that 86% of patients were able to return to preinjury sports activities, likely related to their rib-fixation intervention. Furthermore, 20% (n = 3) of patients reported new medical conditions such as hypertension (n = 3) and depression (n = 2) after experiencing blunt injury to the boney thorax.[16]

Complications

Much of the care for this population is focused on complication-risk reduction and mitigation. Nonetheless complications do occur and are assessed in various ways. Of the 6 studies, 4 addressed complications associated with surgical repair, prolonged intubation, and progression of the underlying lung injury.[12] Mayberry et al[16] found that surgically related complications with rib fixation included deep wound infection (5%; n = 2) and fixation failure (13%; n = 6). Beal and Oreskovich[12] described patient complications related to the progression of the patients' underlying lung injury such as laryngeal injury due to intubation (n = 2), intercostal nerve neuroma (n = 1), loculated pleural cavity (n = 2), and pleural effusion/infiltrate (n = 2). In addition, Chauny et al[14] reported delayed pneumonia in 0.06% (n = 6) of patients after minor thoracic trauma. Death was reported in a single study of patients receiving operative rib fixation (8.7%; n = 2).[17]

Employment

Five of the 6 studies consistently reported on work-related outcomes (eg, lost work time, ability to return to work, and work capacity) as a method of quantifying patient disability.[12,13,15-17] A single study looked at injury-related days of lost work time, with patients losing an average of 70 working days (range, 29-111) because of their injury.[13] Kerr-Valentic et al[13] found that those with isolated thoracic injuries return to work significantly sooner than those with extrathoracic injuries, 51 ± 39 days and 91 ± 33 days, respectively ($P < .01$).

When assessing employment as an outcome measure, it is important to evaluate not only the patients' ability to return to work but also the patients' ability to return to their previous position and overall capability. These topics were assessed in 4 studies.[12,15-17] Mouton et al[17] found that 95% (n = 22) of patients receiving operative rib fixation had returned to full preoperative employment. However, Landercasper et al[15] found that only 43% (n = 12) of patients with flail chest without surgical interventions were able to return to their previous work. Unemployment because of an inability to return to work was reported in 3 studies as 14% (n = 2),[12] 33% (n = 9),[16] and 39% (n = 11)[15] respectively. Limited or part-time work was reported in 7% (n = 1)[12] to 11% (n = 3)[16] of patients, whereas 11% (n = 3)[16] of patients reported an inability to work because of disability associated with this injury pattern.[12,15,16]

DISCUSSION

There is a large quantity of information regarding acute care morbidity and mortality associated with blunt injury to the boney thorax. In contrast, there is a scarcity of evidence related to the posthospitalization, long-term recovery and outcomes. Trauma survivors report that their injuries impact functional status, psychological well-being, quality of life, and return to productivity.[4] Patients with blunt injuries to the boney thorax present a unique challenge to trauma care providers because of severe pain,[5] pulmonary contusion,[22] and complications such as pneumonia,[22-24] therefore limiting adequate pulmonary hygiene and reducing functional residual capacity.[6] Although outcomes are described in the literature, these are generally not associated with a specific injury pattern. In addition, varied methodologies, the small number of identified studies, and relatively small sample sizes present some difficulties when trying to identify consistencies, draw specific conclusions, or translate the evidence into practice. Most notable of these variances relate to differences in assessment times from injury to assessment occurring over days to years. Understanding the science related to the patient and injury characteristics, as well as postinjury assessment findings associated with the long-term outcomes after blunt injuries to the boney thorax, could provide health care teams with critical information to support patients/families and inform their practice.

Patient and Injury Characteristics and Postinjury Assessment Findings

An assortment of patient characteristics has been associated with posthospitalization outcomes after blunt injury to the boney thorax; most notable of these are age and preinjury health. Boney thoracic injuries and mortality increase as patients' age.[24] Unfortunately, the 6 studies in this review reported age as a demographic factor, rather than stratifying the results according to age. Preinjury health and employment status also provide another data point to understand and meet patient-centered goals and expectations. As identified in this review, many patients will need to change the amount or type of work they do for some period of time after injury. This change contributes to the overall personal and society burden associated with the injury.

Injury characteristics offer some insight into potential threats of long-term disability; however, the presence of a severe injury alone is not a major predictor of long-term disability.[7] Richmond[25] describes the greatest impact in long-term outcome in the body region most injured rather than the total injury severity. Severity of injury has been identified as a leading determinant of death, although not an independent predictor of outcomes.[26] Assumptions regarding long-term functioning based solely on injury characteristics and mechanism of injury are not supported in the literature. This literature review revealed study populations sustaining moderate- to severe-injury patterns resulting from both isolated thorax and extrathoracic injuries. This was demonstrated through the reporting of the ISS and the mean number of rib fractures per patient.

However, the correlation between injury type, severity, and outcome was only minimally explored. Nonetheless, as the number of blunt thoracic injuries increases, specifically rib fractures, mortality rate increases.[22,27] It is accepted that the severity of injury plays a role in the anticipated recovery trajectory; however, the studies reviewed did not consistently use the standard ISS to quantify the extent of the injuries.

Various postinjury patient-assessment findings have been identified through this literature review related to posthospitalization outcomes after blunt injury to the boney thorax. As the leading cause of loss of productivity in the United States,[28] many trauma patients require medical help for several years, with as many as 25% requiring trauma-associated medical care at 5 years.[29] Higher levels of postinjury disability are likely influenced by preinjury heath and may be revealed through an understanding of patient-assessment findings after injury. However, the studies reviewed offered little correlation between the pre- and postinjury health status. The impact of prolonged pain, chest deformity, and pulmonary function may last from days to years. Along with complications, the studies reviewed provide supporting evidence related to the societal impact blunt injuries to the boney thorax can have for patients with changes in work abilities, be they temporary, prolonged, or permanent. Interestingly, there is also evidence to suggest that the return to work is not exclusively related to physical and motor impairments, but also due to psychological disturbances from the injury.[30] Unfortunately, the studies in this review did not explore these influences. The magnitude of disability experienced by patients after blunt injury to the boney thorax is well illustrated in these studies. However, the recovery trajectory remains unclear, as the timing of patient assessment was highly variable. More consistent acquisition of data and the timing of assessments should be considered as potential influences when evaluating this data.

Future of Research to Maximize Patient Functional Status

Several studies have shown that sociodemographic factors (ie, age, gender, and educational level), injury-related factors (ie, location, severity of injury, and number of injuries), and psychological factors are major determinants of functional outcomes in the general trauma population.[31-35] This literature review supported many of the same trends associated with previous trauma outcomes research; however, the paucity of blunt thoracic trauma outcome data provides little from which to draw conclusions. Numerous gaps remain related to the correlations between the recovery process and patient characteristics, injury characteristics, and patient-assessment variables.

CONCLUSION

This literature review reinforces the need for further research to expand the body of knowledge related to postinjury long-term outcomes after blunt injury to the boney thorax. Understanding the long-term sequelae not only benefits the individual patient through appropriately timed interventions but may also reduce the societal impact. The transition from traditional trauma-outcomes research based on acute care outcomes to concern for functional impairment is important to the evolution of trauma system development. Reliable evaluation of functional status is needed to fully assess the effectiveness of trauma care.[36] Although prevention of the injury is preferred, efforts to enhance independent functioning and coping are instrumental to the recovery success of this population. Accurate prediction of functional status over time is critical in the development of interventions to mitigate the negative sequelae of traumatic injury.

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