**Note:** This is Online Appendix 1 of Weinberg, B.J., Roos, R. & Van Aswegen, H., 2022, 'Effectiveness of nonpharmacological therapeutic interventions on pain and physical function in adults with rib fractures during acute care: A systematic review and meta-analysis', *South African Journal of Physiotherapy* 78(1), a1764. https://doi. org/10.4102/sajp.v78i1.1764

# Online Appendix 1

**TABLE 1-A1: PubMed database search strings.**

| Search | PubMed syntax | (*N*) Number retrieved |
|---|---|---|
| #1 | (Rib Fracture* OR ''Flail Segment'' OR ''Flail Chest'' Or ''Thoracic Injur*'' OR ''Chest Injur*'' OR ''Chest Trauma'' OR ''Thoracic Trauma'' OR ''Blunt Chest Trauma'' Or ''Blunt Thoracic Trauma'') Filters: Adult: 19 + years | 2354 |
| #2 | (((((Rib Fracture* OR ''Flail Segment'' OR ''Flail Chest'' Or ''Thoracic Injur*'' OR ''Chest Injur*'' OR ''Chest Trauma'' OR ''Thoracic Trauma'' OR ''Blunt Chest Trauma'' Or ''Blunt Thoracic Trauma'')) AND adult[MeSH])) AND Pain) OR ''Acute Pain'' Filters: Adult: 19+ years | 325 |
| #3 | ((((Rib Fracture* OR ''Flail Segment'' OR ''Flail Chest'' Or ''Thoracic Injur*'' OR ''Chest Injur*'' OR ''Chest Trauma'' OR ''Thoracic Trauma'' OR ''Blunt Chest Trauma'' Or ''Blunt Thoracic Trauma'')) AND adult[MeSH])) AND (''Physical Function'' OR ''Physical Activity'' OR Mobility OR Exercise OR ''Functional Activity'' Of Function OR ''Activities of daily living'') Filters: Adult: 19+ years | 171 |
| #4 | ((((Rib Fracture* OR ''Flail Segment'' OR ''Flail Chest'' Or ''Thoracic Injur*'' OR ''Chest Injur*'' OR ''Chest Trauma'' OR ''Thoracic Trauma'' OR ''Blunt Chest Trauma'' Or ''Blunt Thoracic Trauma'')) AND adult[MeSH])) AND (''Respiratory Function'' OR ''Pulmonary Function'' OR Ventilation OR ''Respiratory Status'' OR ''Pulmonary Status'') Filters: Adult: 19+ years | 200 |
| #5 | (((((Rib Fracture* OR ''Flail Segment'' OR ''Flail Chest'' Or ''Thoracic Injur*'' OR ''Chest Injur*'' OR ''Chest Trauma'' OR ''Thoracic Trauma'' OR ''Blunt Chest Trauma'' Or ''Blunt Thoracic Trauma'')) AND adult[MeSH])) AND (Pain OR ''Acute Pain'')) AND (''Physical Function'' OR ''Physical Activity'' OR Mobility OR Exercise OR ''Functional Activity'' Or Function OR ''Activities of daily living'') Filters: Adult: 19+ years | 24 |
| #6 | (((((((Rib Fracture* OR ''Flail Segment'' OR ''Flail Chest'' Or ''Thoracic Injur*'' OR ''Chest Injur*'' OR ''Chest Trauma'' OR ''Thoracic Trauma'' OR ''Blunt Chest Trauma'' Or ''Blunt Thoracic Trauma'')) AND adult[MeSH])) AND (Pain OR ''Acute Pain'')) AND (''Physical Function'' OR ''Physical Activity'' OR Mobility OR Exercise OR ''Functional Activity'' Or Function OR ''Activities of daily living'')) AND adult[MeSH])) AND (''Respiratory function'' OR ''Pulmonary Function'' OR Ventilation OR ''Respiratory Status'' OR ''Pulmonary Status'') Filters: Adult: 19 +years | 7 |

*Source*: Weinberg, B.J., 2020, *The effects of nonpharmacological therapeutic interventions on pain and physical function in adults with rib fractures: A systematic review*, Master's dissertation, University of the Witwatersrand, Johannesburg, viewed 27 April 2022, from https://wiredspace.wits.ac.za/handle/10539/30009.

**TABLE 2-A1:** Search strings.

| Search | Keywords/Search String |
|---|---|
| 7 | #1 AND ("intensive care" OR "critical care" OR "acute care" OR “high care unit” OR hospital OR ward). |
| 8 | #1 AND ("non- pharmacological management" OR “conservative management” OR “non-operative”). |
| 9 | #1 AND (spirometry OR “incentive spirometry”). |
| 10 | # 1 AND ("active cycle of breathing" OR “breathing exercise” OR “deep breathing”). |
| 11 | #1 AND (Physiotherapy OR "physical therapy" OR "respiratory techniques") |
| 12 | #1 AND ("transcutaneous nerve stimulation" OR “TENS” OR “electrotherapy”). |
| 13 | #1 AND (acupuncture OR needling). |
| 14 | # 1 AND ("rib belts" OR braces OR straps). |
| 15 | #1 AND ("taping" OR tape OR kinesiotape OR "dynamic tape" OR “strapping"). |
| 16 | #1 AND (Therapeutic OR Rehabilitation OR therapy OR "Physical Therapy" OR "Physiotherapy" OR “Occupational Therapy” OR Mobilization OR Mobility OR "Physical activity" OR Exercise OR “Functional activity" OR Function OR Multidisciplinary). |
| 17 | #1 AND ("clinical pathways" OR “multidisciplinary clinical pathways” OR "bundled care"). |

*Source*: Weinberg, B.J., 2020, *The effects of nonpharmacological therapeutic interventions on pain and physical function in adults with rib fractures: A systematic review*, Master’s dissertation, University of the Witwatersrand, Johannesburg, viewed 27 April 2022, from https://wiredspace.wits.ac.za/handle/10539/30009.

Filters utilised for all search strategies included: Publication date from 2000/01/01 to 2017/12/31; Humans; English; Adult: 19+ years (where 18 years and older filter was not available for selection).

**#1** Search :( rib fractures") OR ("rib fracture") OR "flail chest") OR ("flail segment") OR "thoracic injury") OR "chest injury") OR "chest trauma") OR "thoracic trauma") OR "blunt chest trauma") OR "blunt thoracic trauma.

Search strategy **#1** was combined with keywords/search strings for setting as well as each non-pharmacological therapeutic intervention (as presented below).

**TABLE 3-A1:** Critical appraisal RCT.

| **Study: RCT** | **Q1 Randomisation to groups** | **Q2 Concealed allocation** | **Q3 Baseline similarity** | **Q4 Subject blinding** | **Q5 Were those delivering treatment blind to treatment assignment** | **Q6 Assessor blinding** | **Q7 Identical group management other than intervention of interest** | **Q8 Follow-up complete *analysis** | **Q9 Intention to treat. (Analysis in groups to randomized** | **Q10 Standardised measurement of outcomes between groups** | **Q11 Reliable measurement of outcomes** | **Q12 Appropriate Statistic analysis** | **Q13. Appropriate trial design** | **Final Critical appraisal score** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Appraisal score per question | 75% | 0% | 100% | 25% | 25% | 50% | 100% | 75% | 100% | 100% | 100% | 100% | 75% | |
| Grammatopoulou et al., (2010) | Yes | Unclear | yes | Unclear | Yes | Yes | yes | yes | Yes | yes | yes | yes | Yes | 11/13 |
| Ho et al., (2014). | Yes | Unclear | Yes | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 11/13 |
| Gunduz et al., (2005). | Yes | Unclear | Yes | No | No | Unclear | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 9/13 |
| Wu et al., (2015). | No | No | Yes | No | No | No | Yes | Unclear | Yes | Yes | Yes | Yes | Unclear | 6/13 |

*Source*: Weinberg, B.J., 2020, *The effects of nonpharmacological therapeutic interventions on pain and physical function in adults with rib fractures: A systematic review*, Master's dissertation, University of the Witwatersrand, Johannesburg, viewed 27 April 2022, from https://wiredspace.wits.ac.za/handle/10539/30009.

**TABLE 4-A1:** Cohort study detailed critical appraisal.

| **Study** | **1. Were the two groups similar and recruited from the same population?** | **2. Were the exposures measured similarly to assign people to both exposed and unexposed groups?** | **3. Was the exposure measured in a valid and reliable way?** | **4. Were confounding factors identified?** | **5. Were strategies to deal with confounding factors stated?** | **6. Were the groups/ participants free of the outcome at the start of the study (or at the moment of exposure)?** | **7. Were the outcomes measured in a valid and reliable way?** | **8. Was the follow up time reported and sufficient to be long enough for outcomes to occur?** | **9. Was follow-up complete, and if not, were the reasons to loss to follow-up described and explored?** | **10. Were strategies to address incomplete follow-up utilised?** | **11. Was appropriate statistical analysis used?** | **Final appraisal rating per study:** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Appraisal score per question:** | **100%** | **100%** | **100%** | **100%** | **50%** | **100%** | **100%** | **83.3%** | **66.7%** | **0%** | **100%** | |
| Curtis et al., (2016). | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Unclear | N/A | Yes | 9/11 |
| Farquhar et al., (2016). | Yes | Yes | Yes | Yes | No | Yes | Yes | Unclear | Unclear | Unclear | Yes | 7/11 |
| Todd et al., (2006). | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | N/A | Yes | 10/11 |
| Flarity et al., (2017). | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | N/A | Yes | 10/11 |
| Sahr et al., (2013). | Yes | Yes | Yes | Yes | N/A | Yes | Yes | Yes | Yes | N/A | Yes | 9/11 |
| Gosnell, (2015). | Yes | Yes | Yes | Yes | N/A | Yes | Yes | Yes | Yes | Unclear | Yes | 9/11 * |

*Source*: Weinberg, B.J., 2020, *The effects of nonpharmacological therapeutic interventions on pain and physical function in adults with rib fractures: A systematic review*, Master's dissertation, University of the Witwatersrand, Johannesburg, viewed 27 April 2022, from https://wiredspace.wits.ac.za/handle/10539/30009.

*, The cohort study conducted by Gosnell, [54] scored 9/11, but was excluded as the primary outcomes of this systematic review were not evaluated/reported.

**TABLE 5-A1:** Case reports detailed critical appraisal.

| **Study** | **1. Were patient's demographic characteristics clearly described?** | **2. Was the patient's history clearly described and presented as a timeline?** | **3. Was the current clinical condition of the patient on presentation clearly described?** | **4. Were diagnostic tests or assessment methods and the results clearly described?** | **5. Was the intervention(s) or treatment procedure(s) clearly described?** | **6. Was the post-intervention clinical condition clearly described?** | **7. Were adverse events (harms) or unanticipated events identified and described?** | **8. Does the case report provide takeaway lessons?** | **Final appraisal rating per study:** |
|---|---|---|---|---|---|---|---|---|---|
| **Appraisal score per question :** | **100%** | **50%** | **66.7%** | **66.7%** | **66.7%** | **50%** | **33.3%** | **83.3%** | |
| Michelet & Boussen, (2013). | Yes | No | No | Yes | No | No | No | Yes | 3/8 |
| Callaghan & Phelan, (2011). | Yes | No | No | No | No | No | No | Unclear | 1/8 |
| Garfield & Howard-Griffin, (2000). | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 8/8 |
| Linton & Sviri, (2006). | Yes | Yes | Yes | No | Yes | Yes | No | Yes | 6/8 |

*Source*: Weinberg, B.J., 2020, *The effects of nonpharmacological therapeutic interventions on pain and physical function in adults with rib fractures: A systematic review*, Master's dissertation, University of the Witwatersrand, Johannesburg, viewed 27 April 2022, from https://wiredspace.wits.ac.za/handle/10539/30009.

**TABLE 6-A1:** Critical appraisal of systematic review and research syntheses.

| Study | 1. Is the review question clearly and explicitly stated? | 2. Were the inclusion criteria appropriate for the review question? | 3. Was the search strategy appropriate? | 4. Were the sources and resources used to search for studies adequate? | 5. Were the criteria for appraising studies appropriate? | 6. Was critical appraisal conducted by two or more reviewers independently? | 7. Were there methods to minimize errors in data extraction? | 8. Were the methods used to combine studies appropriate? | 9. Was the likelihood of publication bias assessed? | 10. Were recommendations for policy and/or practice supported by the reported data? | 11. Were the specific directives for new research appropriate? | Final appraisal rating: |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Johnson et al., (2015). | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 11/11 |

*Source*: Weinberg, B.J., 2020, *The effects of nonpharmacological therapeutic interventions on pain and physical function in adults with rib fractures: A systematic review*, Master's dissertation, University of the Witwatersrand, Johannesburg, viewed 27 April 2022, from https://wiredspace.wits.ac.za/handle/10539/30009.

**TABLE 7-A1:** Analytical cross sectional study detailed appraisal.

| **Study** | **1. Were the criteria for inclusion in the sample clearly defined?** | **2. Were the study subjects and the setting described in detail?** | **3. Was the exposure measured in a valid and reliable way?** | **4. Were objective, standard criteria used for measurement of the condition?** | **5. Were confounding factors identified?** | **6. Were strategies to deal with confounding factors stated?** | **7. Were the outcomes measured in a valid and reliable way?** | **8. Was appropriate statistical analysis used?** | **Final appraisal rating:** |
|---|---|---|---|---|---|---|---|---|---|
| Mehta, (2013). | Yes | Initially :Unclear | Initially :Unclear | Yes | No (not documented) | No (not documented) | Yes | No<br><br>Only averages to depict changes were utilised. No further statistical method of analysis was conducted on the results obtained. | :3/8 –**>** 5/8 (Clarification by author Q2 & Q3 increased final appraisal score). |

*Source*: Weinberg, B.J., 2020, *The effects of nonpharmacological therapeutic interventions on pain and physical function in adults with rib fractures: A systematic review*, Master's dissertation, University of the Witwatersrand, Johannesburg, viewed 27 April 2022, from https://wiredspace.wits.ac.za/handle/10539/30009.

**TABLE 8-A1:** Text and opinion studies detailed appraisal.

| **Study** | **1. Is the source of the opinion clearly identified?** | **2. Does the source of opinion have standing in the field of expertise?** | **3. Are the interests of the relevant population the central focus of the opinion?** | **4. Is the stated position the result of an analytical process, and is there logic in the opinion expressed?** | **5. Is there reference to the extant literature?** | **6. Is any incongruence with the literature/sources logically defended?** | **Final appraisal rating per study:** |
|---|---|---|---|---|---|---|---|
| Appraisal score per question: | 100% | 100% | 100% | 80% | 100% | 100% | |
| Unsworth et al., (2015). | Yes | Yes | Yes | Yes | Yes | Yes | 6/6 |
| Easter, (2001). | Yes | Yes | Yes | Unclear<br>The manuscript was composed in a logical manner, however it was unclear how the literature was sourced (searches conducted and databases searched). | Yes | Yes | 5/6 |
| Ekpe & Eyo., (2016). | Yes | Yes | Yes | Yes | Yes | Yes | 6/6 |
| Simon et al., (2012). | Yes | Yes | Yes | Yes | Yes | Yes | 6/6 |
| Witt &Bulger, (2017). | Yes | Yes | Yes | Yes | Yes | Yes | 6/6 |

*Source*: Weinberg, B.J., 2020, *The effects of nonpharmacological therapeutic interventions on pain and physical function in adults with rib fractures: A systematic review*, Master's dissertation, University of the Witwatersrand, Johannesburg, viewed 27 April 2022, from https://wiredspace.wits.ac.za/handle/10539/30009.

**TABLE 9-A1:** Summary of findings.

**Summary of findings:**

**Bundled care compared to standard/ usual care for inpatients with acute rib fractures**

**Patient or population**: inpatients with acute rib fractures
**Setting**: Acute care
**Intervention**: bundled care
**Comparison**: standard/ usual care

| Outcomes | Anticipated absolute effects* (95% CI) | | Relative effect (95% CI) | № of participants (studies) | Certainty of the evidence (GRADE) | Comments |
|---|---|---|---|---|---|---|
| | **Risk with standard/ usual care** | **Risk with bundled care** | | | | |
| Hospital length of stay (LOS) | The mean hospital length of stay ranged from **4.77-14.3** days [a] | MD **0.1 days fewer** (0.98 fewer to 0.77 more) | - | 994 (3 observational studies) | ⨁⨁⨁◯ MODERATE [b] | Bundled care intervention indicated a possible increase or decrease in LOS by one day following intervention. Final point estimate CI were inclusive of null effect.Evidence was rated down based on imprecision criteria. |
| Pneumonia incidence | 12 per 100 | **5 per 100** (2 to 8) | **RR 0.37** (0.20 to 0.67) | 846 (2 observational studies) | ⨁◯◯◯ VERY LOW [c] | Overall results indicated a relative risk reduction of 63% of pneumonia following bundled care intervention versus standard/usual care. Evidence rated down based on imprecision. Inconsistency was rated not serious with I2=26%. |
| Mortality rate | 5 per 100 | **3 per 100** (2 to 6) | **RR 0.62** (0.32 to 1.23) | 1691 (3 observational studies) | ⨁◯◯◯ VERY LOW [d] | Overall point estimate indicated reduced relative risk of mortality by 38% following bundled care. Final CI advocated potential reduction in relative mortality risk by 32% or increased risk of 23% followed bundled care. Evidence was rated down on imprecision criteria and inconsistency was deemed not serious in the presence of explainable heterogeneity. |

***The risk in the intervention group** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).

**CI:** Confidence interval; **MD:** Mean difference; **RR:** Risk ratio

**GRADE Working Group grades of evidence**
**High certainty:** We are very confident that the true effect lies close to that of the estimate of the effect
**Moderate certainty:** We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different
**Low certainty:** Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect
**Very low certainty:** We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

**Explanations**

a. Range derived from studies included in the meta-analysis.
b. The confidence interval is inclusive of null effect, with minimally important difference demonstrated in the overall point estimate.
c. Overall sample sizes and number of events are small.
d. Relatively few events and wide confidence intervals including potential for appreciable benefit and harm.

*Source*: Weinberg, B.J., 2020, *The effects of nonpharmacological therapeutic interventions on pain and physical function in adults with rib fractures: A systematic review*, Master's dissertation, University of the Witwatersrand, Johannesburg, viewed 27 April 2022, from https://wiredspace.wits.ac.za/handle/10539/30009.

**TABLE 10-A1**: Baseline characteristics and clinical profile of included studies.

| ***Authors*** | ***Study design*** | ***Country*** | ***Setting*** | ***Patient number (N)*** | | ***Age*** | | ***Gender (%)*** | | ***Mechanism of injury*** | ***Rib fractures included:*** | ***Associated thoracic injuries. %*** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Gunduz et al. (2005).** | RCT | Turkey | Hospital ICU. | (43) | | Total (N):<br>Age range:<br>23-49 yrs. | | Total (N):<br>Male: (62.8%):<br>Female: (37.2%) | | Blunt thoracic trauma. *(Exact mechanism not specified)* | Multiple / **Flail** | *Haemothorax*<br>(C):19%: (I):27.3%.<br><br>*Pneumothorax*<br>(C): 42.8%: (I):50%.<br><br>*Haemopneumothorax*<br>(C):14.2%):(E):9.1%<br><br>*Tension pneumothorax*<br>(C) 4.76%: (I):0% |
| | | | | COM:n=21 | INT: n=22 | COM:<br>Mean age: 38 (10) yrs. | INT:<br>Mean age: 40 (9) yrs. | COM:<br>Male: n=14 (66.7%)<br>Female: n=7 (33.3%) | INT:<br>Male: n=13 (59.1%)<br>Female: n=9 (40.9%) | | | |
| **Grammatopoulou et al. (2010).** | RCT | Greece | General Hospital | (90) | | Age range: 45-75 yrs.<br>Mean age :58.02 ( ±9.55) | | Total (N):<br>Male (78.9%):<br>Female (21.1%) | | **Mobile accidents* : 61.1%<br><br>*Falls* :38.9% | ≥ 3 | *Pneumothorax*<br>(C):40% (I):56.6%<br><br>*Pulmonary contusion*<br>(C):51.1% (I):51.1%<br><br>*Haemothorax*<br>(C):33.3% (E) 46.7% |
| | | | | COM n=45 | INT n=45 | COM:<br>Mean age: 56.91 (8.86) yrs. | INT:<br>Mean age: 59.13 (10.17) yrs. | COM:<br>Male: n=33 (73.3%)<br>Female: n=12 (26.7%) | INT:<br>Male: n=37 (82.2%)<br>Female: n=8 (17.8%). | | | |

| *Authors* | *Study design* | *Country* | *Setting* | *Patient number (N)* | | *Age* | | *Gender (%)* | | *Mechanism of injury* | *Rib fractures included :* | *Associated thoracic injuries. %* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | |
| **Ho et al. (2014).** | RCT | Taiwan | Hospital Inpatients | (58). | | ≥18 yrs. | | Total (N): Male (69%): Female (31%) | | *Traffic accident* :67.2%<br><br>*Falls*: 29.3%.<br><br>*Crush injuries*: 3.4% | ≥ 1 uni/ Bilateral.<br><br>Mean No. rib #s per group = 3 | *Pneumothorax* (I):4.8% : (C):26.3%<br><br>*Hemothorax* (I):28.6%: (C) :26.3%<br><br>*Hemopneumothorax* (E) :23.8% (C) :26.3% |
| | | | | COM:n=29 | INT: n=29 | COM: Mean age :46.7±41.6 | INT: Mean age 52.7±15.2 | COM : Male: n=21 (72.4%) Female: n=8 (27.6%) | INT: Male: n=19 (65.5%) Female n=10 (34.5%) | | | |
| **Sahr et al. (2013).** | Cohort | USA | Hospital Trauma ICU. | (148) | | 65yrs or older | | Total (N): Male: (51.35%): Female: (39.19%) | | Falls :56.08%<br><br>MVA: 28.38%<br><br>Other: | <3 & > 3 | Not specified |

| *Authors* | *Study design* | *Country* | *Setting* | *Patient number (N)* | | *Age* | | *Gender (%)* | | *Mechanism of injury* | *Rib fractures included:* | *Associated thoracic injuries. %* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | COM: n=81 | INT: n= 67 | COM:<br><3 rib #: Mean age: 79.70 (7.88)<br>> 3 rib #: Mean age: 79.06 (8.50) | INT:<br><3 rib #: Mean age: 79.64 (9.37)<br>> 3 rib #: Mean age: 79.54 (8.11) | COM:<br>Male n=46 (56.8%)<br>Female n=35 (43.2%) | INT:<br>Male n=30 (44.8%)<br>Female n=37 (55.2%) | 8.78% | COM:<br><3 : n=30<br>> 3: n= 51<br>INT:<br><3 : n=28<br>> 3: n=39 | |
| **Flarity et al. (2017).** | Cohort | USA | Hospital ICU | (571) | | Median age: 58 yrs. (interquartile range 28-75) yrs. | | Male: (60%): Female: (40%) | | Blunt mechanism of injury. | 1 or > rib #'s.<br>Median No rib # per cohort: 3.<br>Bilateral & flail chest included. | *Sternal fractures :*<br>Pre-cohort: 3%<br>Post cohort: 2%<br>*Flail chest:*<br>Pre-cohort: 1.2%<br>Post cohort: 1,9% |
| | | | | COM n=252<br>ICU: n=111 | INT: n=319<br>ICU: n=163 | COM: 56 (40-73) yrs.<br>COM ICU: 52 (31-67). | INT: 60 (46-75) yrs.<br>INT ICU: 57 (45-73). | COM: Male (57.9%) Female (42.1%).<br>ICU: Male (65.8%). Female (34.2%). | INT: Male (62.1%): Female (37.9%)<br>ICU: Male (63.8%) Female (36.2%) | | | |
| **Curtis et al. (2016).** | Cohort | Australia | Hospital: level 1 trauma centre | 546 | | | | Male: (45.4%): Female: (54.6%). | | *Fall < 1 m: 83.9%<br>*Fall > 1 m: 6.2%<br>*MVA: | Rib fracture/s | *Haemothorax:*<br>Pre-cohort :9.9%<br>Post-cohort:10.6%<br>*Pneumothorax:* |

| *Authors* | *Study design* | *Country* | *Setting* | *Patient number (N)* | | *Age* | | *Gender (%)* | | *Mechanism of injury* | *Rib fractures included :* | *Associated thoracic injuries. %* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | COM: n=273 | INT: n=273 | COM : Median age 82 yrs. interquartile range: (71–88) | INT: Median age 81 yrs. I interquartile range: (70–87) | COM: Male (43.6%) Female (56.4%) | INT: Male (47.3%) Female (52.7%) | 4.6% *Vulnerable road user :2% *Other: 3.3% | | Pre-cohort: 5.9% Post-cohort: 3.7% *Pulmonary Contusion.* Pre-cohort: 4% Post-cohort: 2% |
| **Todd et al. (2006).** | Cohort | America | Hospital ICU | 300 | | > 45 yrs. | | Male: (63.7%): Female :( 36.3%) | | Blunt thoracic trauma | > 4 COM cohort: 6 (5–7) rib #. INT cohort: 7 (6–9) rib #. | *Sternal fracture* Pre-cohort :5% Post-cohort :10% *Pulmonary contusion* Pre-cohort :37% Post-cohort : 33% *Hemothorax* Pre-cohort :15% Post-cohort :43% *Pneumothorax* Pre-cohort : 39% Post-cohort :53% *Hemo/pneumothorax* Pre-cohort :14% Post-cohort :29% *Flail chest* |
| | | | | COM:150 | INT: 150 | COM cohort: Age: 60.5 (52-72) yrs. | INT cohort: Age: 56 (51–65) yrs. | COM cohort: Male (64.7%): Female (35.3%) | INT cohort: Male (62.7%) Female (37.3%) . | | | |

| *Authors* | *Study design* | *Country* | *Setting* | *Patient number (N)* | *Age* | *Gender (%)* | *Mechanism of injury* | *Rib fractures included :* | *Associated thoracic injuries. %* |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Pre-cohort : 5%<br>Post-cohort: 27% |
| **Mehta.(2013)** | Analytical Cross-sectional study | India | Hospital | N=7 | 18-70 years | Male (71.4%): Female (28.6%) | Blunt chest trauma | *Rib fracture**s*** . | Not specified |

| *Authors* | *Study Design* | *Country* | *Setting* | *Patient Number (N)* | *Age* | *Gender* | *Mechanism of injury* | *Rib fractures included:* | *Associated thoracic injuries. %* |
|---|---|---|---|---|---|---|---|---|---|
| **Linton & Sviri. (2006).** | *Case Report* | Jerusalem, Israel. | Hospital. ICU | 1 | 82 yr. old. | Female | Blunt chest trauma (Vigorous cardiopulmonary resuscitation). | Flail chest | None |
| **Garfield & Howard-Griffin. (2000).** | Case Report | England | Accident & emergency department ICU | 1 | 35 yr. old. | Male | Road traffic accident. | Flail chest. | Pulmonary contusions Pneumothoraces |
| **Papadopoulos et al. (2017).** | Case Report | Greece | Emergency department. Advanced care unit. | 1 | 60 yr. old. | Male | MVA | Multiple | Pneumothorax Pulmonary contusion. Fracture sternum |

*Source*: Weinberg, B.J., 2020, *The effects of nonpharmacological therapeutic interventions on pain and physical function in adults with rib fractures: A systematic review*, Master's dissertation, University of the Witwatersrand, Johannesburg, viewed 27 April 2022, from https://wiredspace.wits.ac.za/handle/10539/30009.

COM-comparator group, #- fracture/s, INT- intervention group, ICU-intensive care unit, IPPB- intermittent positive pressure breathing, No. –number, MVA- motor vehicle accident, vulnerable road user-collision involving cyclist, motorbike or pedestrian, Yr. - year

**TABLE 11-A1:** Baseline characteristics of Included Text & Opinion Studies.

| *Authors (Citations)* | *Type of text* | *Country* | *Setting* | *Population represented* | *Topic of interest* |
|---|---|---|---|---|---|
| **Easter. (2001).** | Review article<br>Protocol recommendation | USA | Hospital: ICU | Blunt chest trauma<br>Multiple rib fractures. | Management of patients with multiple rib fractures.<br>Protocol development. |
| **Unsworth et al. (2015).** | Literature review : integrative review | Australia | In hospital | Blunt chest trauma.<br>Rib fractures<br>Flail | Comprehensive overview of treatment modalities & clinical INTs and their impact on patient and hospital outcomes. |
| **Ekpe & Eyo. (2016).** | Review article: Literature review | Nigeria | In-hospital management. | Blunt chest injury.<br>Multiple rib fractures.<br>Trauma. | Approaches to pain management in blunt chest injury (multiple rib fractures) & observed complications. |
| **Simon et al. (2012).** | Practice management guideline.<br>Updated EAST practice management | USA | In hospital | Pulmonary contusion & flail chest (PC-FC). | Management of pulmonary contusion & flail chest. |
| **Witt & Bulger. (2017).** | Review.<br>Harborview rib fracture management protocol. | USA | In-hospital management.<br>Acute care | Blunt chest trauma.<br>Multiple rib fractures | Comprehensive management of multiple rib fractures.<br>Bundled rib fracture management protocol. |

*Source*: Weinberg, B.J., 2020, *The effects of nonpharmacological therapeutic interventions on pain and physical function in adults with rib fractures: A systematic review*, Master's dissertation, University of the Witwatersrand, Johannesburg, viewed 27 April 2022, from https://wiredspace.wits.ac.za/handle/10539/30009.

**TABLE 12-A1:** Interventions and outcomes of included studies.

| Authors | Study design | Control group and treatment received. | Intervention group and treatment received. | Outcomes evaluated | Description of main results & conclusion |
|---|---|---|---|---|---|
| **Gunduz et al. (2005).** | RCT | Control: n=21<br>**Rx**: MV via endotracheal intubation (IPPV via ETI).<br>Chest physiotherapy (percussion and vibration) was initiated following pain control in all patients. | Experimental group (n = 22):<br>**Rx**: CPAP (face mask) & Patient Controlled Analgesia (PCA).<br>Chest physiotherapy (percussion and vibration) was initiated following pain control in all patients. | **Verbal Rating score** (in CPAP group) & morphine use.<br>**ICU LOS.**<br><br>**Infections/ complications.**<br><br>ICU survival rate.<br><br>Complications with IPPV or CPAP use. | **Verbal rating scores** & morphine consumptions decreased with time in the CPAP group.<br>**Mean LOS:** ( p>0.05):<br>CPAP :16 days (3) v ETI : (4) days<br>(No significant differences in length of ICU stay between groups)<br>**Pneumonia**: p<0.00 ETI group (n=10); CPAP group (n=2) (48% vs 9%):<br>Spontaneous breathing with CPAP permits better bronchial hygiene.<br><br>Mortality<br>ET group n=7/21 : CPAP group: n=2/22<br>CPAP group survival: p <0.01<br>No complications associated with IPPV or CPAP use.<br>**Conclusion:** Non-invasive CPAP with PCA led to lower mortality and incidence of pneumonia. Oxygenation & ICU LOS stay were similar. Findings suggest that CPAP may be utilised as a first step in the treatment of flail chest following blunt thoracic trauma. |

| Authors | Study design | Control group and treatment received. | Intervention group and treatment received. | Outcomes evaluated | Description of main results & conclusion |
|---|---|---|---|---|---|
| **Grammatopoulou et al. (2010).** | RCT | n=45<br>Treatment= routine physiotherapy: positioning, early mobilisation, supportive coughing (hands/ pillow but not rib belt), IS (QID) + analgesia received. | n=45<br>Treatment = ACBT BD (first three days) & once a day (remaining four days) + analgesia received.<br>All patients received analgesic therapy & routine physiotherapy. | VAS: *during cough daily post physio session &<br>* 2 hrs. post analgesia.<br><br>Respiratory volumes (Flow-oriented incentive spirometer Triflo II)<br>Pulmonary complications<br>*Secretions *WCC: *Temperature. | Pain: Day 3 (p =0 .04) & days 4 -7 (p = 0.00) **->** favoured ACBT intervention.<br>Significant reduction across day to day treatment for both groups. ACBT lower mean pain scores & faster, more linear reduction in pain vs control.<br>Incentive Spirometry volumes: not recorded.<br>Pulmonary function tests: not conducted due to pain.<br><br>**Pulmonary complications: not detected in either group.**<br>Secretions: no pathological findings.<br>WBC: p=0.02 btw groups on day 7. Temperature: (p>0.05).<br>**Conclusion**: ACBT lead to pain reduction but did not prevent pulmonary complications compared to routine physiotherapy. No pulmonary complications were however detected in either group and may be as a result of chest physiotherapy instituted. |
| **Ho et al. (2014).** | RCT | Thumbtack intradermal (TI) needles group (Control group): n=25.<br>TI treatment: Once daily; 5 needles retained 6 hrs. /day. | Filiform needles (FN) group (Intervention group): n=27.<br>Daily treatment, 3 consecutive days since enrolment. Identical doses of analgesia provided to both groups.<br>FN treatment: Once daily: 5 needles retained 6 hrs. /day. | **Pain** (NRS: 0 to10) assessed during :<br>*deep breathing, *coughing<br>*turning in bed.<br><br>**Duration** of pain relief.<br><br>**Sustained maximal inspiration (SMI)** lung volumes.<br><br>Sleep disturbance NRS (0 to10). | ***Pain intensity** FN group: control group: under all assessed conditions= p < 0.05 for FN (except during deep breathing after the 1st & 2nd treatments (p > 0.05).<br>FN group patients reported elevated motivation to get up & move, as well as reduced pain with turning over in bed.<br>***≥ 6hrs maintained pain relief:**<br>81.5% FN group : 40% control group.<br><br>***SMI** immediate lung volumes after 2nd acupuncturing: (p < 0.05):<br>FN group SMI 142.60 ± 204.10 ml: control group 6.00 ± 143.10 ml (p < 0.01). p>0.05 after third treatment.<br>Sleep quality p<0.05 sleep (1st intervention) thereafter p>0.05.<br>Conclusion: FN acupuncture intervention resulted in reduced pain intensity during activities of deep breathing, coughing, |

| Authors | Study design | Control group and treatment received. | Intervention group and treatment received. | Outcomes evaluated | Description of main results & conclusion |
|---|---|---|---|---|---|
| | | | | | and turning over. Acupuncture management reduced the inconvenience due to trauma and improved the QOL of patients during hospitalisation. |
| **Mehta, 2013** | Analytical Cross-Sectional Study | | One group with n=7 participants.<br><br>Rx= TENS<br>Dual channel high TENS (120 Hz), 30 mins at site of pain. | *__VAS__: 0-10<br>*__PEFR__ (l/min).<br>*Arterial blood (__$SpO_2$__): via pulse oximeter.<br>(Assessed before & immediately after TENS use). | *Mean difference VAS reduction:6.43 to 3<br>*__PEFR:__ 90 to 121.43(L/min) following TENS use: Breathing capacity improved due to pain relief.<br>*__$SpO_2$__: 97.28% to 99% following TENS.<br>No complications due to TENS therapy noted.<br>**Conclusion**: TENS was effective in controlling pain with resultant improvement in pulmonary function. |

*Source*: Weinberg, B.J., 2020, *The effects of nonpharmacological therapeutic interventions on pain and physical function in adults with rib fractures: A systematic review*, Master's dissertation, University of the Witwatersrand, Johannesburg, viewed 27 April 2022, from https://wiredspace.wits.ac.za/handle/10539/30009.

Key: ACBT- active cycle of breathing technique, BD- twice a day, CPAP- continuous positive airway pressure, ETI- endotracheal intubation, hrs.- hours, ICU- intensive care unit, IPPV- intermittent positive pressure ventilation, IS- incentive spirometry, LOS- length of stay, MV- mechanical ventilation, NRS- numeric rating scale, PEFR- peak expiratory flow rate, QID- four times a day, Rx= treatment, SpO2- oxygen saturation, TENS- Transcutaneous electrical nerve stimulation, VAS- visual analogue scale, WCC- white cell count, Yrs.- years.

**TABLE 13-A1:** Interventions and outcomes of included cohort studies.

| Study | Study design | Control cohort and management. | Intervention cohort and management. | Outcomes evaluated. | Description of main results & conclusion. |
|---|---|---|---|---|---|
| **Sahr et al. (2013).** | Cohort | Pre-Protocol Implementation group n=81: *Retrospective cohort* <3 rib fracture : n=30 > 3 rib fracture: n=51. | Post-Protocol Implementation: n=67: *Triage protocol multidisciplinary care.* <3 rib fracture n=28 > 3 rib fracture n=39 *Treatment included*: aggressive pain control (PCA), early mobilisation, *multidisciplinary care* (physical therapy & rehabilitation, social work, & pharmacy included). | Hospital LOS. ICU LOS. | When comparing the number of ribs fractured: patients with 3 or more rib fractures had longer lengths of stay: Hospital LOS p=0.04 & ICU LOS p=0.03 Comparison of pre versus post- protocol phases for hospital LOS: p=0.01, favouring post-protocol intervention. Conclusion: Standardisation of management via protocol implementation and access to multidisciplinary care decreased hospital LOS in elderly patients with three or more rib fractures. |
| **Flarity et al. (2017).** | Cohort | Total Pre-clinical practice guideline (CPG): N=252 Of which ICU cohort n=111 | Total Post-clinical practice guideline (CPG): N=319 Of which ICU cohort :n=111 Management = Early FVC, aggressive analgesia, identify respiratory deterioration. FVC screening guided Rx. **FVC less than 1000 mL:** trauma intensive care unit. *aggressive pulmonary toilet *mandatory consult: loco-regional anesthesia pain service. | Hospital LOS. ICU LOS. Mortality rate | **Total Pre-CPG: Post-CPG** Hospital LOS : p=0.93 ICU LOS: p=0.22 A separate analysis was performed on patients admitted to the ICU to evaluate the most severely injured cohort. **ICU Cohort Pre-CPG: Post-CPG** * CPG cohort: ↑ ICU admission *↓ ICU LOS >2 days for patients admitted to ICU post CPG. **Mortality** Total cohort : p=0.76 ICU cohort : p=0.95 **Conclusion :** * CPG (bedside FVC, early identification of respiratory compromise, & early loco-regional analgesia) resulted in ↓ LOS. * Rib fracture CPG =early identification of at risk patients & provided consistency in provider practice. *ISS, rib fractures & CPG = predictive for LOS. |
| **Curtis et al. (2016).** | Cohort | Cohort 1 : Pre- CHiP activation group: n=273 (Retrospective cohort). | Cohort 2 : Post CHiP activation group: n=273 Initial management = Incentive Spirometry + humidified HFNP oxygen + multimodal analgesia, PCA. *MDT care: physiotherapy, pain & trauma team review. | **Primary Outcome:** Pneumonia **Clinical outcomes** Mortality rate Health service outcomes **Hospital LOS** | **Pneumonia** :p=0.03 **Pre-CHiP incidence of pneumonia:* n=25 (9.2%) vs Post-CHiP n=12 (4.4%) * 56% reduction in odds of developing pneumonia in Post-CHIP cohort. **Mortality rate** reduction after CHiP implementation p=0.29. *Pre- ChIP:6 (2.2%) deaths vs 2 (0.7%) in Post-ChIP. **Hospital LOS** p=0.74 (ISS & nISS p<0.00). Non-significant difference in LOS potentially due to : |

| Study | Study design | Control cohort and management. | Intervention cohort and management. | Outcomes evaluated. | Description of main results & conclusion. |
|---|---|---|---|---|---|
| | | | | Time to specific MDT personal review (physiotherapy, trauma team). | * ISS higher in post ChIP cohort.<br>* LOS being affected by a multitude of factors, ot only management implemented.<br>Post ChIP cohort :<br>*pain & trauma team review p<0.00 & PCA p=0.04<br>*physiotherapy (p=0.01) & earlier review by 4hrs *HFNP $0_2$ : p<0.00<br>Conclusion - ChIP resulted in:<br>*consistent management approach<br>*facilitated multidisciplinary review<br>*reduced pneumonia incidence and mortality rate. |
| **Todd et al. (2006).** | Cohort | Pre-pathway: n=150: (Historic controls prior to the pathway's inception). | Post-pathway: n=150:<br>**Management:** PCA & incentive spirometry (on admission).<br>Screening for entry into multidisciplinary pathway (MDP):<br>*VAS(during incentive spirometry/coughing)<br>*Inspiratory volumes (IS)<br>*Cough effort<br>Failure of set criteria => MDT<br>MDT: respiratory therapy, physical therapy, pain and nutrition services.<br>Respiratory therapy (volume expansion protocol: aerosolized pharmacologic therapies, EzPAP positive airway pressure system).<br>Physical therapy (mobility: strengthening, ROM, & balance exercises). | ICU LOS.<br>Hospital LOS.<br>Pneumonia incidence.<br>Mortality rate. | Adjusted analysis for (age, ISS & No.rib fractures ) *favoured post pathway intervention:*<br>*ICU LOS (p=0.01) :decreased stay by 2.4 days<br>*Hospital LOS (p=0.02), reduced by 3.7 days.<br>*Pneumonia (p <0.00):<br>*Mortality (p= 0.06): favouring post-pathway cohort.<br>**Conclusion**: rib fracture MDT clinical pathway implementation resulted in decreased ICU & hospital LOS, incidence of pneumonia, and mortality rate. |

*Source*: Weinberg, B.J., 2020, *The effects of nonpharmacological therapeutic interventions on pain and physical function in adults with rib fractures: A systematic review*, Master's dissertation, University of the Witwatersrand, Johannesburg, viewed 27 April 2022, from https://wiredspace.wits.ac.za/handle/10539/30009.

Key: ChIP- chest injury protocol, EzPAP- positive expiratory pressure system, FVC- forced vital capacity, HFNP- high flow nasal prong oxygen, ICU-intensive care unit, ISS- injury severity score, IS- incentive spirometry, LOS- length of stay, PCA- patient controlled analgesia, MDP- multidisciplinary pathway, MDT- multidisciplinary team, ROM- range of movement, Yrs.- years, VAS- visual analogue scale.

**TABLE 14-A1:** Management and final results of included case reports.

| Study | Type of study | Management &/or outcome reviewed | Description of main results |
|---|---|---|---|
| **Linton & Sviri. (2006).** | Case Report | Continuous negative extrathoracic pressure (CNEP) ventilation strategy (cuirass ventilator): continuous negative pressure = −15cmH2O. | CNEP use: successful ventilation, weaning & extubation of a patient following flail chest post blunt chest trauma.<br>CNEP: splinting effect **->** increases FRC & improves lung mechanics.<br>Splinting effect CNEP **->** Cough and analgesia more effective.<br>Preserves ability to talk, eat & breathe freely.<br>May reduce incidence of laryngeal injury and ventilator-associated complications. |
| **Garfield & Howard-Griffin. (2000).** | Case Report | ICU admission.<br>Day 1: Volume controlled ventilation - tracheal intubation & left & right ICD.<br>Day 3: Thoracic epidural and PCA.<br>**Day 5**: **CPAP (facemask) & IPPV**.<br>**Day 12**: **(continuous NIPPV via nasal mask).**<br>**Day 20: Intermittent NIPPV & $O_2$ nasal cannulae.**<br>**Day 25: nocturnal CPAP via facemask.**<br>Day 26: discharged to the ward. | NIPPV is safe & effective in thoracic trauma management.<br>CPAP & NIPPV effective in ventilatory management.<br>No VAP/septic complications (pulmonary or systemic).<br>Non-invasive ventilation reduced incidence of VAP. |
| **Papadopoulos et al. (2017).** | Case Report | Auricular acupuncture | Auricular acupuncture lead to:<br>***rapid pain (VAS) relief** and anxiety reduction (decline HR & BP).<br>1st acupuncture VAS: 10/10 to "complete regression of chest pain".<br>2nd acupuncture: VAS 10/10 (before): 3/10 (after).<br>***restoration of deep breathing**, effective cough, normal ventilation (respiratory rate & saturation), oxygenation (ABG) & haemodynamic profile.<br>**1st session**: $SpO_2$ on 5L/min O2 via facemask = 82% (before acupuncture): $SpO_2$ = 92% (after acupuncture).<br>$PaCO_2$= 48mmHg (before acupuncture) : 38mmHg (after acupuncture)<br>**2nd acupuncture session:** 79% (before acupuncture): 97-100% (after acupuncture).<br>Normalisation of ABG. |

*Source*: Weinberg, B.J., 2020, *The effects of nonpharmacological therapeutic interventions on pain and physical function in adults with rib fractures: A systematic review*, Master's dissertation, University of the Witwatersrand, Johannesburg, viewed 27 April 2022, from https://wiredspace.wits.ac.za/handle/10539/30009.

Key: ABG- arterial blood gas, BP- blood pressure, COPD- chronic obstructive pulmonary disease, CNEP- continuous negative extrathoracic pressure, CPAP- continuous positive airway pressure, FRC- functional residual capacity HR- heart rate, ICD- intercostal drain, ICU-intensive care unit, IPPB- intermittent positive pressure breathing, MVA- motor vehicle accident, NIPPV- non-invasive positive pressure ventilation, PaCO2-partial pressure of carbon dioxide in arterial blood, SpO2-oxygen saturation, Yr.- year, VAS- visual analogue scale, VAP- ventilator associated pneumonia.

**TABLE 15-A1:** Findings and conclusions of Included Text and Opinion studies.

| Author | Type of text | Stated allegiance/position/topic reviewed : | Description of main findings/argument(s) |
|---|---|---|---|
| **Easter. (2001).** | Review article Protocol review & recommendation. | *Hypothesis:* Rapid mobilisation, respiratory support & pain management will decrease ICU LOS. | Management practices to be included in the care of patients with multiple rib fractures:<br>* Appropriate pain management: facilitates better outcomes and minimises complications.<br>* Rapid mobilisation<br>* Respiratory support<br>= key factors in preventing pulmonary complications. |
| **Unsworth et al. (2015).** | Literature review : integrative review | Currently no published reviews evaluating all potential treatment options for blunt chest trauma.<br>Review of clinical interventions & treatments for rib fractures and their impact on patient and hospital outcomes. | **Treatment modalities with significant evidence for their benefit & which collectively improve hospital outcomes (ICU & hospital LOS) & patient outcomes (including mortality and morbidity) were identified :**<br>**1)Analgesia**<br>*Epidural analgesia (*3/more rib fractures) lead to improved pain relief & pulmonary function.<br>*Effective pain control is necessary to allow for deep breathing chest physiotherapy and improved lung function.<br>**2) Surgical rib fixation for flail chest** -> improves patient outcomes.<br>**3) Transdisciplinary clinical pathways.**<br>* Vital component of management following multiple rib fractures.<br>* Standardise practice & facilitate multidisciplinary care.<br>* Allied health (chest physiotherapy & nutritionist input), nursing, medical (analgesic review) & surgical intervention (stabilisation of flail chest) recommended as part of the multi-disciplinary approach.<br>* Rapid mobilisation through physiotherapy is considered a key factor in preventing respiratory complications. |
| **Ekpe & Eyo. (2016).** | Review article: Literature review | Review of analgesic modalities available for pain control in blunt chest injury with multiple rib fractures: with a view to advising on the best treatment modalities available. | Appropriate analgesia assists in ameliorating respiratory morbidity and mortality following traumatic multiple rib fractures.<br>Pain management modalities identified:<br>*systemic, regional (more measurable evidence) & transcutaneous.<br>Preferred mode of management for blunt chest trauma:<br>*Pain control, chest physiotherapy, & mobilisation **->** reduce respiratory morbidity and mortality**.**<br>TENS (paucity of data in use in management of multiple rib fractures). |
| **Simon et al. (2012).** | Practice management guideline.<br>Updated EAST | **PC & flail chest (PC-FC)** prevalent complex injury.<br>Mortality & short term morbidity form PC-FC have | All studies were graded by an established committee according to the standards recommended by the EAST Ad Hoc Committee for Guideline Development with evidence presented as follows:<br>**Level 1 recommendation**: no support for level 1 recommendations regarding PC-FC.<br>**Level 2 recommendations:** |

| Author | Type of text | Stated allegiance/position/topic reviewed : | Description of main findings/argument(s) |
|---|---|---|---|
| | practice management | not improved during the last three decades.<br>Updated EAST practice mx guideline (evidence-based recommendations) for Rx of PC-FC are presented. | *PEEP or CPAP (ventilatory regimen). *Avoid obligatory MV<br>***Aggressive chest physiotherapy** *Optimal analgesia (epidural catheter for severe flail chest).<br>**Level 3 recommendations:**<br>*Trial mask CPAP (meeting criteria for use).<br>*Surgical fixation in severe flail chest failing to wean or thoracotomy required.<br>*Multidisciplinary protocols*: may improve outcome/considered where feasible.<br>High-frequency oscillatory ventilation (HFOV): Not shown to improve survival in blunt chest trauma patients. |
| **Witt & Bulger. (2017).** | Review.<br>Harborview rib fracture management protocol. | Comprehensive approach & review of intervention strategies used in the management of patients with multiple rib fractures..<br>Implementation & review of a *multidisciplinary rib fracture management protocol.* | Multidisciplinary bundled care pathways are recommended for the care of patients with multiple rib fractures.<br>Multimodal pain management, respiratory therapy interventions, and frequent re-evaluation should form part of these pathways.<br>*Harborview Bundled care pathway & management protocol:*<br>***PIC** (Pain, Inspiratory capacity, and Cough) scoring tool to serially evaluate and monitor patients together with frequent assessment & re-evaluation -> guided care.<br>*multimodal systemic analgesia & acute pain service if required/ catheter-based analgesia<br>*hourly pulmonary hygiene *early, frequent mobilisation<br>*elevation of head of bed *patient and family education & empowerment<br>*Incentive spirometry (assessment & treatment purposes). *Respiratory therapy ( frequent evaluation & care)<br>* Multidisciplinary team involvement encompassed (*nursing staff, respiratory therapists, physicians & acute pain services).* |

*Source*: Weinberg, B.J., 2020, *The effects of nonpharmacological therapeutic interventions on pain and physical function in adults with rib fractures: A systematic review*, Master's dissertation, University of the Witwatersrand, Johannesburg, viewed 27 April 2022, from https://wiredspace.wits.ac.za/handle/10539/30009.

Key: CPAP- continuous positive airway pressure, ICU-intensive care unit, LOS-length of stay, MV- mechanical ventilation, PC- pulmonary contusion, PEEP- positive end expiratory pressure.