Does cardiopulmonary resuscitation cause rib fractures in children: a systematic review
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CRD summary
This review concluded that rib fractures after cardiopulmonary resuscitation in children are rare and, where they do occur, they are anterior and multiple. Further research using more sensitive methods for detecting rib fractures is, however, required. This was a well-conducted review and the authors' conclusions are likely to be reliable.

Authors' objectives
To determine the frequency and characteristics of rib fractures associated with cardiopulmonary resuscitation (CPR) in children.

Searching
ASSIA, CareData, ChildData, CINAHL, EMBASE, ISI Proceedings, MEDLINE, Ovid MEDLINE In-Process and Other Non-Indexed Citations, the Science Citation Index, the Social Sciences Citation Index, SIGLE and TRIP were searched from 1950 to October 2005 for articles in any language. Twenty-two keywords and combinations of keywords were used (details were not reported). In addition, reference lists, textbooks and conference abstracts were searched.

Study selection
Study designs of evaluations included in the review
Reviews, expert opinions, consensus guidelines and studies that were methodologically flawed were excluded. In all of the included studies, the data were collected retrospectively.

Specific interventions included in the review
Studies of external closed CPR were eligible for inclusion. Where reported, the duration of resuscitation in the included studies ranged from 1 to 540 minutes and resuscitation was performed by medical personnel, bystanders, or a combination of both. None of the included studies described the CPR technique.

Participants included in the review
Studies of children (aged up to 18 years) with no underlying bone disease were eligible for inclusion. Studies with mixed populations of adults and children were excluded if the results for children were not reported separately. The included studies were in children aged 0 to 14 years. Five of the six included studies excluded prior child abuse. Five studies evaluated children who had died; the sixth evaluated children who had survived.

Outcomes assessed in the review
Studies that assessed rib fractures were eligible for inclusion. The included studies collected outcomes data from medical case reports, radiographic examinations and autopsy reports. Five of the six studies obtained information about rib fractures at postmortem examination; in the sixth, rib fractures were identified using chest X-rays after CPR (64% of children had only early post-resuscitation X-rays and the others had follow-up X-rays at 2 weeks). None of the studies used specimen radiography.

How were decisions on the relevance of primary studies made?
The studies were selected for inclusion at two independent reviews undertaken by a panel of 27 reviewers. Any disagreements were resolved at a third review.

Assessment of study quality
The studies were assessed for study design, extent to which pre-existing rib fractures and medical conditions were excluded, tendency to bone fragility prior to resuscitation and methods used to identify rib fractures. The studies were
assessed at two independent reviews undertaken by a panel of 27 reviewers. Any disagreements were resolved at a third review.

**Data extraction**
The data were extracted, using a standardised form, at two independent reviews undertaken by a panel of 27 reviewers. The number of children with rib fractures was extracted from each study.

**Methods of synthesis**
How were the studies combined?
The studies were combined in a narrative.

How were differences between studies investigated?
Differences between the studies were discussed in the text or were apparent from inspection of the tables presented.

**Results of the review**
Six studies (n=923) were included: one case-control study (n=324), four cross-sectional studies (n=549) and one case series (n=50).

Three of the 923 children were diagnosed with rib fractures: two babies aged 2 and 3 months who died of sudden infant death syndrome and one 5-year-old who drowned. All of the fractures were anterior and multiple (two cases had mid-clavicular rib fractures and one had bilateral rib fractures at the sternochondral junction). There were no posterior fractures associated with CPR.

**Authors’ conclusions**
Rib fractures after CPR were rare. Where they did occur, they were anterior and multiple. Further research using more sensitive methods for detecting rib fractures is required.

**CRD commentary**
The review addressed a clear question that was defined in terms of the participants, intervention, outcomes and study design. An extensive search was undertaken and attempts were made to minimise language and publication bias. Methods were used to minimise reviewer errors and bias in the study selection, validity assessment and data extraction processes. Validity was assessed using criteria that seemed appropriate for the topic, and adequate information on the included studies was presented. In view of the diversity of the studies, the narrative synthesis was appropriate and differences between the studies were discussed. This was a well-conducted review and the authors’ conclusions are likely to be reliable.

**Implications of the review for practice and research**
Practice: The authors did not state any implications for practice.

Research: The authors stated that more definitive evidence may come from prospective studies of children undergoing CPR that use more sensitive radiological and autopsy methods to identify rib fractures.

**Funding**

**Bibliographic details**
Maguire S, Mann M, John N, Ellaway B, Sibert J R, Kemp A M. Does cardiopulmonary resuscitation cause rib

PubMedID
16857258

DOI
10.1016/j.chiabu.2005.12.007

Indexing Status
Subject indexing assigned by NLM

MeSH
Adolescent; Cardiopulmonary Resuscitation /adverse effects /statistics & numerical data; Causality; Child; Child Abuse /diagnosis /statistics & numerical data; Child, Preschool; Clavicle /injuries; Cross-Sectional Studies; Diagnosis, Differential; Humans; Infant; Rib Fractures /diagnosis /epidemiology /etiology; Risk Factors; Sternocostal Joints /injuries

AccessionNumber
12006008407

Date bibliographic record published
30/06/2007

Date abstract record published
30/06/2007

Record Status
This is a critical abstract of a systematic review that meets the criteria for inclusion on DARE. Each critical abstract contains a brief summary of the review methods, results and conclusions followed by a detailed critical assessment on the reliability of the review and the conclusions drawn.