Injury, Int. J. Care Injured xxx (2018) xxx–xxx

Contents lists available at ScienceDirect

Injury

journal homepage: www.elsevier.com/locate/injury

Review

Chest ultrasonography for the emergency diagnosis of traumatic pneumothorax and haemothorax: A systematic review and meta-analysis

Leonardo Jönck Staub[a,f,*], Roberta Rodolfo Mazzali Biscaro[b], Erikson Kaszubowski[e], Rosemeri Maurici[c,d]

[a] Emergency Department, University Hospital, Federal University of Santa Catarina, 88036-800, Rua Professora Maria Flora Pausewang, Bairro Trindade, Florianópolis, Santa Catarina, Brazil
[b] Intensive Care Unit, University Hospital, Federal University of Santa Catarina, Florianópolis, Santa Catarina, Brazil
[c] Department of Clinical Medicine, Federal University of Santa Catarina, Florianópolis, Santa Catarina, Brazil
[d] Graduate Program in Medical Sciences, Federal University of Santa Catarina, Florianópolis, Santa Catarina, Brazil
[e] Department of Psychology, Federal University of Santa Catarina, Florianópolis, Santa Catarina, Brazil
[f] Intensive Care Unit, Nereu Ramos Hospital, Florianópolis, Santa Catarina, Brazil

ARTICLE INFO

Article history:
Accepted 29 January 2018

Keywords:
Ultrasonography
Pneumothorax
Haemothorax
Trauma
Emergency department
Diagnostic accuracy

ABSTRACT

Objective: To assess the diagnostic of the chest ultrasonography for the emergency diagnosis of traumatic pneumothorax and haemothorax in adults.
Study design: Systematic review and meta-analysis.
Methods: PubMed, EMBASE, Scopus, Web of Science and LILACS (up to 2016) were systematically searched for prospective studies on the diagnostic accuracy of ultrasonography for pneumothorax and haemothorax in adult trauma patients. The references of other systematic reviews and the included studies were checked for further articles. The characteristics and results of the studies were extracted using a standardised form, and their methodological quality was assessed using the Quality Assessment of Diagnostic Accuracy Studies (QUADAS-2). Primary analysis was performed considering each hemithorax as an independent unit, while secondary analysis considered each patient. The global diagnostic accuracy of the chest ultrasonography was estimated using the Rutter–Gatsonis hierarchical summary ROC method. Moreover, Reitsma's bivariate model was used to estimate the sensitivity, specificity, positive likelihood ratio (LR +) and negative likelihood ratio (LR–) of each sonographic sign. This review was previously registered (PROSPERO CRD42016048085).
Results: Nineteen studies were included in the review, 17 assessing pneumothorax and 5 assessing haemothorax. The reference standard was always chest tomography, alone or in parallel with chest radiography and observation of the chest tube. The overall methodological quality of the studies was low. The diagnostic accuracy of chest ultrasonography had an area under the curve (AUC) of 0.979 for pneumothorax (**Fig**). The *absence of lung sliding and comet-tail artefacts* was the most reported sonographic sign of pneumothorax, with a sensitivity of 0.81 (95% confidence interval [95%CI], 0.71–0.88), specificity of 0.98 (95%CI, 0.97–0.99), LR+ of 67.9 (95%CI, 26.3–148) and LR– of 0.18 (95%CI, 0.11–0.29). An *echo-poor or anechoic area in the pleural space* was the only sonographic sign for haemothorax, with a sensitivity of 0.60 (95%CI, 0.31–0.86), specificity of 0.98 (95%CI, 0.94–0.99), LR+ of 37.5 (95%CI, 5.26–207.5), LR– of 0.40 (95%CI, 0.17–0.72) and AUC of 0.953.
Conclusion: Notwithstanding the limitations of the included studies, this systematic review and meta-analysis suggested that chest ultrasonography is an accurate tool for the diagnostic assessment of traumatic pneumothorax and haemothorax in adults.

* Corresponding author at: Emergency Department, University Hospital, Federal University of Santa Catarina, 88036-800, Rua Professora Maria Flora Pausewang, Bairro Trindade, Florianópolis, Santa Catarina, Brazil.
E-mail address: leonardo.staub@ufsc.br (L.J. Staub).

https://doi.org/10.1016/j.injury.2018.01.033
0020-1383/

Contents

Introduction

A rapid diagnosis of pneumothorax and haemothorax is essential in trauma patients, since chest drainage can be life-saving. Chest radiography (CXR) is currently the first diagnostic method when clinical examination does not indicate immediate thoracostomy. However, various studies have reported the low sensitivity of CXR for these injuries [1–3]. The image quality is lower in patients in the decubitus position and when using portable devices. In addition, CXR requires patient mobilisation and radiation exposure.

In this context, chest ultrasonography has attracted attention in recent years [4]. It is portable, fast, and easily reproducible; moreover, it does not use radiation, and it allows real-time scanning and interpretation [5]. Pneumothorax is assessed in the more anterior chest regions. The pleural line, a horizontal hyperechoic line just below the surface of the rib, can easily be identified on an ultrasonography scan. The presence of *lung sliding*, a slight, bright movement of the pleural line during the respiratory cycle, indicates adhesion between the visceral and parietal pleura. In addition, the presence of *comet tail artefacts*, vertical hyperechoic artefacts arising from the pleural line, indicates the subpleural presence of the lung parenchyma. Thus, the absence of these two signs may suggest a separation between the visceral and parietal pleura containing air, representing a pneumothorax. The most lateral chest point, where lung sliding or comet tail artefacts are again visualised, is called the *lung point*. This sign is specific for pneumothorax, since it excludes other causes of *absence of lung sliding and comet-tail* artefacts, such as bullous emphysema or pleural adherences [4,5]. Haemothorax and other causes of pleural effusion are assessed in a more posterior-basal chest region. An anechoic or hypoechoic image between the diaphragm and parietal pleura, with inspiratory movement of visceral pleural in the pleural space, indicates a pleural effusion [4,5].

The available data suggest the excellent diagnostic performance of chest ultrasonography for overall pneumothoraces and pleural effusions [6–8]. However, as for CXR, the care of acute trauma patients imposes some obstacles to chest ultrasonography. Patients are immobilised and receiving other diagnostic and therapeutic interventions, and they usually cannot collaborate with the examination. Thus, evidence on nontraumatic pneumothorax and pleural effusions cannot be totally applied to the trauma context.

The aim of this systematic review and meta-analysis was to assess the accuracy of chest ultrasonography for the emergency diagnosis of pneumothorax and haemothorax in adult trauma patients. This study systematically reviews the evidence available in the prospective diagnostic accuracy studies of chest ultrasonography for these injuries. In addition, summary measures are determined for the overall diagnostic accuracy of chest ultrasonography and for the individual diagnostic accuracy of the sonographic signs.

Methods

The protocol of this review was previously registered in the International Prospective Register of Systematic Reviews (PROSPERO CRD42016048085). The review is reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [9].

Two independent authors selected and reviewed the studies, extracted the data and assessed the methodological quality. Discrepancies were resolved by discussion until a consensus was reached. In cases where a consensus could not be reached, a third author resolved the issue.

Data sources and search

With the aid of a biomedical librarian, PubMed, EMBASE, Scopus, Web of Science, and LILACS were searched for studies published up to December 2016. The search terms covered concepts related to ultrasonography, thorax and emergency departments (EDs)/ICUs. The final database search strategy is

Please cite this article in press as: L.J. Staub, et al., Chest ultrasonography for the emergency diagnosis of traumatic pneumothorax and haemothorax: A systematic review and meta-analysis, Injury (2018), https://doi.org/10.1016/j.injury.2018.01.033