Ambient Science, 2016: Vol. 03(2); 12-15
DOI:10.21276/ambi.2016.03.2.rv02

ambient
SCIENCE
Vol. 3(2): 12-15
Year 2016

Published by: National Cave Research and Protection Organization, India

REVIEW ARTICLE

Ultrasound Guidance in Detection of Pneumothorax and Thoracentesis Performance: a Review

Hamed Amini Ahidashti, Seyed Mohammad Hoseininejad*

Emergeny Medicine department, Mazandaran University of medical sciences, Sari, Iran

Key words: Ultrasonography, Chest radiography

Abstract

Management of pneumothorax and its early diagnosis are important clinical skills for physicians in emergency departments and respiratory medicine. The recent investigations provide some evidence about the use of ultrasonography in the diagnosis of pneumothorax in critical care units. Currently, ultrasonography is used in most therapeutic and diagnostic departments for both detection and disease management. Advantages of ultrasonography are that it's portable and can be applied on patient's bedside. In this article, we reviewed the efficacy of ultrasonography in the diagnosis of pneumothorax and its performance in Thoracentesis. We concluded that diagnostic accuracy of ultrasonography was equal and sometimes more than chest radiography in the detection of pneumothorax. Ultrasonography will increase patient safety, the amount of fluid removed during thoracentesis and can reduce the risk of pneumothorax, hospitalization costs and length of stay.

Introduction:

There are two forms of pneumothorax; spontaneous and traumatic. There is no history of trauma in Spontaneous pneumothorax which has two subgroups consisting of primary or secondary (Papagiannis *et al.,* 2015).Primary spontaneous pneumothorax is common in young and normal individuals whereas secondary spontaneous pneumothorax is caused due to lung and other pathologies like the chronic obstructive pulmonary disease, cystic fibrosis .The frequency of pneumothorax is higher in patients with underlying lung disease (MacDuff *et al.*, 2010). A study indicated that age-adjusted incidence of primary spontaneous pneumothorax is 7.4 per 100,000 per year in men and 1.2 per 100,000 per year in women. For secondary spontaneous pneumothorax, the incidence was 6.3 and 2.0 per 100,000 per year in men and women. They reported that ratio of male-to-female incidence was 6.2:1 for primary and 3.2:1 for secondary spontaneous pneumothorax (Melton *et al.*, 1979).

Reports also suggest cases of hospital admitted rates for both primary and secondary spontaneous pneumothorax in the United Kingdom were 16.7 per 100,000 for male and 5.8per 100,000 for female, with corresponding annual mortality rates of 1.26 per million and 0.62 per million between 1991 and 1995 (Gupta *et al.,* 2000).

Different aspect of ultrasound (US) has been developed in past few decades for diagnosis, staging and restaging follow-up (Sbolli *et al.*, 1990; Cavanna *et al.*, 1992; Civardi *et al.*, 2002). Chest trauma and allied problems consisted of 25% of mortalities in this series and are commonly responsible for 40% mortality rate (Hill, 2011; Heron, 2012). Although CXR has insufficient efficacy but it is the first step in managing chest trauma (Wilkerson & Stone, 2010; Xirouchaki *et al.*, 2011; Rodriguez *et al.*, 2013; Forouzanfar *et al.*, 2014).

Pneumothorax is one of the major complications of trauma in multiple trauma patients and its proper diagnosis is very important to save a life. However, very few studies have been conducted in this regard (Tang *et al.,* 2012; Kline *et al.,* 2013; Fankhauser *et al.,* 2013; Barbara, 2014; Aspler *et al.,* 2014).Utilizing the US in diagnosis and management of patients is well described for some conditions but Thoracic sonography is a new method and the process is still under investigation. In this regard the first US to detect pneumothorax was performed by

*Corresponding Author: drhoseininejad@yahoo.com

ISSN- 2348 5191 (Print) & 2348 8980 (Electronic)

Ambient Science, 2016: Vol. 03(2); 12-15
DOI:10.21276/ambi.2016.03.2.rv02

Wernecke *et al.,* (1987). Therefore in the current article, we reviewed the efficacy of Thoracic sonography in the diagnosis of Pneumothorax in traumatic patients and its efficacy in thoracentesis.

Thoracentesis:

Ultrasound has the ability to show 20 mL of pleural fluid, but upright posteroanterior CXR can reveal at least 100 mL of fluid (Rahman *et al.,* 2010; Turner & Dankoff, 2012) visceral pleural puncture, one of the reasons for pneumothorax is the most considerable complication of thoracentesis (Gordon *et al.,* 2010).

The rate of pneumothorax after Thoracentesis is about as 20% to 39% (Grogan, 1990). Using US provide evidence about the correct place of needle insertion depth into the intercostal space (Grogan, 1990; Sassoon *et al.,* 1992). We should consider that many articles which discussed US-guided thoracentesis revealed needle insertion time was no real-time guidance and insert the needle right after US probe detection (Feller-Kopman, 2006). Nevertheless, reports also revealed that after inadequate clinical thoracentesis, use of US can develop the procedure up to 88% and has high success rate. Sometimes we found dry taps' patients but in 58% of these cases needle is below the diaphragm and US is the only remedy (Weingardt *et al.,* 1994; Diacon *et al.,* 2003; Barnes *et al.,* 2005). In a systematic review and meta-analysis, Gordon *et al.* (2010) revealed the best way to lessen the pneumothorax rates after thoracentesis is considering the US.

Patel *et al.* (2012) indicated that considering US for thoracentesis would decrease total hospital stay, reduce costs and lower incidence of pneumothorax and hemorrhage. The Patient Protection and Affordable Care Act of 2010 and the Centers for Medicare and Medicaid Services Reporting Hospital Quality Data for Annual Payment Update Program Quality Measures FY 2012–2014 describe as important aim for high efficacy in healthcare, safer and considerable medical care, including the avoidance of preventable complications and iatrogenic pneumothorax (Shojania *et al.,* 2001; PPACA, 2012; DHHS, 2012). US is an easily learned technique which is portable and effective in a reliable physical exam and could provide real-time guidance for thoracentesis and other procedures (Feller-Kopman, 2007). Cavanna *et al.* (2014) reported that using the US during thoracentesis drastically would decrease the rate of pneumothorax and tube thoracostomy in cancerous objects.

Pneumothorax:

A pneumothorax has two main etiology; traumatic and atraumatic. Atraumatic pneumothorax has been divided to primary spontaneous or secondary spontaneous. For detecting pneumothorax currently, we use clinical signs and symptoms, as well as subtle and plain chest radiography. Wastage of time in diagnosing a pneumothorax could result in progression of a pneumothorax and resultant hemodynamic instability (Bridges *et al.*, 1993).

Although the gold standard diagnosis of pneumothorax is CT scan but it has been seen that the sensitivity of US is the same. (Soldati *et al.,* 2008). Moreover emergency departments, Meta-analysis Reports also revealed the sensitivity of 78.6–90.9 % and specificity of 98.2–98.4 % for US which chests radiographs had showed sensitivity of 39.8–50.2 % and specificity of 99.3–99.4 % (Alrajhi *et al.,* 2012; Alrajab *et al.*, 2013).

Lung sliding, B-lines, lung pulse, and lung point are some features which can help pneumothorax to be detected or omitted by the US (Volpicelli *et al.*, 2012).Lung sliding or B-lines can exclude pneumothorax when we report them on the anterior surface of a supine patient's chest (Lichtenstein *et al.,* 2005; Soldati *et al.*, 2008; Ebrahimi *et al.*, 2014; Kristensen *et al.*, 2014; Obrador *et al.,* 2014). A meta-analysis by Ebrahimi *et al.* (2014) indicated that the diagnostic accuracy of US was higher than supine CXR for diagnosis of pneumothorax. They indicated sensitivity and specificity of US were 0.87 and 0.99. The pooled sensitivity and specificity of CXR were 0.46 and 1.0, respectively. A study by Kristensen *et al* (2014) showed that Ultrasonography is a reliable device for intraoperative and emergency diagnosis of pneumothorax. The US provide us diagnosis and management of interstitial syndrome, lung consolidation, atelectasis, pleural effusion and differentiate etiologies of acute breathlessness during pregnancy.

Limitations:

The ultrasound (US) can be considered as an alternative for CXR but its accuracy depends on operator's skill and knowledge. However, progressions in structural changes of US improved the quality and spatial resolution which resulted in better outcomes in emergency departments. (Obrador *et al.*, 2014; Haghighi *et al.*, 2014; Heydari *et al.*, 2014; Xirouchaki et al., 2014; Williams *et al.*, 2014; Mundada *et al.*, 2014; See *et al.,* 2014; Wagner *et a l.*, 2014).

Probe selection and equipment:

Diagnosis of pneumothorax can be applied in the bedside of the patients by many of the current devices. Maybe a straight linear array high-frequency probe (5-13 MHz) can be adequate in detecting superficial structures including the pleural line and providing better resolution (Mundada *et al.,* 2014). Most micro convex transducers can provide a reliable image for both superficial (pleura) and deeper structures (e.g. lung consolidation, atelectasis). Due to their small size they can indicate posterior thoracic wall in the supine position. In this regards, curved low-frequency transducer (~4.0 MHz), can show superficial and deeper structures in high-quality images. (Laursen et al., 2011; Volpicelli *et al.*, 2012).

Conclusion:

Many current investigations reveal the safety and efficacy of US-guided thoracentesis which can reduce the risk of hospitalization costs, pneumothorax and duration of recovery. Based on available reports and meta-analysis ultrasonography could be considered as having reliable accuracy and is more accurate than chest radiography for diagnosis of pneumothorax. Conclusively, ultrasonography in emergency departments for both traumatic and non-traumatic patients for detection of pneumothorax is being advised.

Acknowledgements:

The authors are grateful to thanks emergency medicine departments nurses for secretarial assistance.

References:

Alrajhi, K., Woo, M.Y. & Vaillancourt, C. (2012): Test characteristics of ultrasonography for the detection of pneumothorax: a systematic review and meta-analysis. *Chest.* 141:703-708.

Alrajab, S., Youssef, A.M., Akkus, N.I. & Caldito, G. (2013): Pleural ultrasonography versus chest radiography for the diagnosis of pneumothorax: review of the literature and meta-analysis. *Crit. Care,* 17(5): 208.

Aspler, A., Pivetta, E. & Stone, M.B. (2014): Double-lung point sign in traumatic pneumothorax. *Am.J.Emerg.Med.,* 32(7):819 e1-2.

Barbara, D.W. (2014): **Bedside Lung Ultrasonography: A Tool for Rapid Assessment of Pneumothorax.** Anesthesiology.

Barnes, T.W., Morgenthaler, T.I., Olson, E.J., Hesley, G.K., Decker, P.A. & Ryu, J.H. (2005): Sonographically guided thoracenteses and rate of pneumothorax. *J Clin Ultrasound.* 33:442446

Bridges, K.G., Welch, G., Silver, M., Schinco, M.A. & Esposito, B. (1993): CT detection of occult pneumothorax in multiple trauma patients. *J. Emerg Med.,* 11:179-186.

Cavanna, L., Civardi, G., Fornari, F., Di Stasi, M., Sbolli, G. & Buscarini, E. (1992): Ultrasonically guided percutaneous splenic tissue core biopsy in patients with malignant lymphomas. *Cancer,* 69:2932-2936

Cavanna, L., Mordenti, P., Bertè, R., Palladino, M.A., Biasini, C., Anselmi, E., Seghini, P., Vecchia, S., Civardi, G. & Di Nunzio, C. (2014). Ultrasound guidance reduces pneumothorax rate and improves safety of thoracentesis in malignant pleural effusion: report on 445 consecutive patients with advanced cancer. *World J. Surg. Oncol.* 12: 139.

Civardi, G., Vallisa, D., Berte', R., Lazzaro, A., Moroni, C.F. & Cavanna, L. (2002): Focal liver lesions in non-Hodgkin's lymphoma: investigation of their prevalence, clinical significance and the role of Hepatitis C virus infection. *Eur. J. Cancer.* 38:2382-2387.

DHHS (Department of Health and Human Services) (2012): Hospital inpatient prospective payment systems for acute care hospital and longterm care hospital prospective payment system and FY 2012 rates; Hospital's FTE resident caps for graduate medical education payment.US Government Printing Office website.

Diacon, A.H., Brutsche, M.H. & Soler, M. (2003): Accuracy of pleural punctures sites: a prospective comparison of clinical examination with ultrasound. *Chest,* 123:436-441

Ebrahimi, A., Yousefifard, M., Kazemi, H.M., Rasouli, H.R., MoghadasJafari, H.A. & Hosseini, M. (2014): Diagnostic Accuracy of Chest Ultrasonography versus Chest Radiography for Identification of Pneumothorax: A Systematic Review and Meta-Analysis. *Tanaffos;* 13(4): 29-37.

Fankhauser, G.T., Fowl, R.J., Stone, W.M. & Money, S.R. (2013): Elimination of pneumothorax and hemothorax during placement of implantable venous access ports using ultrasound and fluoroscopic guidance. Vascular.

Feller-Kopman, D. (2006): Ultrasound-guided thoracentesis. Chest. 129:1709-1714.

Forouzanfar, M.M., Safari, S., Niazazari, M., Baratloo, A., Hashemi, B., Hatamabadi, H.R., Rahmati, F., Sanei, Taheri M. (2014): Clinical decision rule to prevent unnecessary chest X-ray in patients with blunt multiple traumas. *Emerg. Med. Australas.,* 26(6):561-566

Gordon, C.E., Feller-Kopman, D., Balk, E.M. & Smetana, G.W. (2010): Pneumothorax following thoracenteses. *Arch Intern Med*. 4:332-339.

Grogan, D.R., Irwin, R.S., Channick, R., Raptopoulos, V., Curley, F.J., Bartter, T. & Corwin, R.W. (1990): Complications associated with thoracenteses: a prospective, randomized study comparing three different methods. *Arch. Intern. Med.,* 150:873-877.

Gupta, D., Hansell, A. & Nichols, T. (2000): Epidemiology of pneumothorax in England.Thorax, 55:666-671.

Haghighi, S.H.O., Begi, M.H.R. & Sorkhabi, R., Tarzamani, M.K., Zonouz, G.K., Mikaeilpour, A. & Rahamani, F. (2014). Diagnostic Accuracy of Ultrasound in Detection of Traumatic Lens Dislocation.*Emergency;* 2(3):121-124.

Heron, M. (2012) Deaths : leading causes for 2008. *Natl. Vital Stat. Rep.,* 60(6):194

Heydari, F., Esmailian, M. & Dehghanniri, M. (2014): Diagnostic Accuracy of Ultrasonography in the Initial Evaluation of Patients with Penetrating Chest Trauma. *Emergency* 2(2):81-84.

Hill, A., Fowler, R., Pinto, R. & Nathens, A. (2011): Epidemiology of major trauma: a Canadian perspective. *Can. J. Surg.,* 54(3):S45.

Kline, J.P., Dionisio, D., Sullivan, K., Early, T., Wolf, J. & Kline, D. (2013): Detection of pneumothorax with ultrasound. *AANAJ.*, 81(4):265-271.

Kopman-Feller, D. (2007): Ultrasound-guided internal jugular access: a proposed standardized approach and implications for training and practice. *Chest,* 132:302-309.

Kristensen, M.S., Teoh, W.H., Graumann, O. & Christian, B. (2014): Laursen.Ultrasonography for clinical decision-making and intervention in airway management: from the mouth to the lungs and pleurae. *Insights Imaging,* 5(2): 253-279.

Laursen, C.B., Knudsen, L., Bendtsen, T.F. & Sloth, E. (2011): Lungeultralydskanning (LUS) In: Bitsch M, Jensen F, edt. **KliniskUltralydskanning.** Copenhagen: FADL's Forlag. p. 167-179.

Lichtenstein, D.A., Mezière, G. & Lascols, N. (2005): Ultrasound diagnosis of occult pneumothorax.*Crit. Care Med.,* 33:1231-1238.

MacDuff, A., Arnold, A. & Harvey, J. (2010): Management of

Verify it

Ambient Science, 2016: Vol. 03(2); 12-15
DOI:10.21276/ambi.2016.03.2.rv02

spontaneous pneumothorax: British Thoracic SocietyPleural Disease Guideline. *Thorax:* 65Suppl 2:18-31.

Melton, L.J. 3rd, Hepper, N.G. & Offord, K.P. (1979): Incidence of spontaneous pneumothorax in Olmsted County, Minnesota: 1950 to 1974. *Am Rev Respir Di.,* 120:1379-1382.

Mundada, S.D., Gosavi, K.S. & Kondvilkar, B. (2014). Use of ultrasound to diagnose pneumothorax after video assisted thoracic surgery: Do we need to acquire a new skill?. *Saudi J Anaesth.* 8(4): 550-553.

Obrador, Z.L., Al-Lal, Y.M., de-Tomás, P.J., Prats, A.I. & Fuentes, T.F. (2014): Transmediastinal and transcardiac gunshot wound with hemodynamic stability. *Case Rep Surg*: Article ID- 985097, 3 pages

Patel, P.A., Ernest, F.R. & Gunnarsson, C.L. (2012) : Ultrasonography guidance reduces complications and costs associated with thoracentesis procedures. *J Clin Ultrasound.* 40:135-141.

Papagiannis, A., Lazaridis, G., Zarogoulidis, K., Papaiwannou, A., Karavergou, A., Lampaki, S. & Baka, S. (2015): Pneumothorax: an up to date "introduction". *Ann. Transl. Med.,* 3(4):53.

(PPACA) Patient Protection &Affordable Care Act (2012). US Government Printing Office website: http://www.gpo.gov/fdsys/pkg/PLAW-111publ148/html/PLAW-111publ148.htm

Rahman, N.M., Singanayagam, A., Davies, H.E., Wrightson, J.M., Mishra, E.K. & Lee, Y.C. (2010): Diagnostic accuracy, safety and utilisation of respiratory physician-delivered thoracic ultrasound. *Thorax.* 65(5):449-453.

Rodriguez, R.M., Anglin, D., Langdorf, M.I., Baumann, B.M., Hendey, G.W. & Bradley, R.N. (2013): NEXUS chest: validation of a decision instrument for selective chest imaging in blunt trauma. *JAMA Surg.,* 148(10):940-946.

Sassoon, C.S., Light, R.W., O'Hara, V.S. & Moritz, T.E. (1992): Iatrogenic pneumothorax: etiology and morbidity: results of a Department of Veterans Affairs Cooperative Study. *Respiration.* 59:215-220.

Sbolli, G., Fornari, F., Civardi, G., Di Stasi, M., Cavanna, L., Buscarini, E. & Buscarini, L. (1990): Role of ultrasound guided fine needle aspiration biopsy in the diagnosis of hepatocellular carcinoma. *Gut.* 31:1303-1305

See, K.C., Ong, V., Teoh, C.M., Ooi, O.C., Widjaja, L.S. & Mujumdar, S. (2014): Bedside pleural procedures by pulmonologists and non-pulmonologists: a 3-year safety audit. *Respirology.* 19(3):396-402

Shojania, K.G., Duncan, B.W. & McDonald, K.M., Wachter, R.M., Markowitz, A.J. (2001): Making health care safer: a critical analysis of patient safety practices. *Evid Rep Technol Assess (Summ)* 43:1-668.

Soldati, G., Testa, A., Sher, S., Pignataro, G., La Sala, M. & Silveri, N.G. (2008): Occult traumatic pneumothorax: Diagnostic accuracy of lung ultrasonography in the emergency department. *Chest.* 133:204-2011

Tang, H., Pan, T., Qin, X., Xue, L., Wu, B. & Zhao, X. (2012): A portable thoracic closed drainage instrument for hemo-pneumothorax. *J. Trauma Acute Care Surg.,* 72(3):671-675.

Turner, J.P. & Dankoff, J. (2012): Thoracic ultrasound. *Emerg Med Clin North Am.,* 30(2):451-73

Volpicelli, G., Elbarbary, M. & Blaivas, M. (2012): International evidence-based recommendations for point-of-care lung ultrasound. *Intensive Care Med.,* 38:577-591

Wagner, M.S., Garcia, K. & Martin, D.S. (2014): Point-of-care ultrasound in aerospace medicine: known and potential applications. *Aviat Space Environ Med.,* 85(7):730-739.

Weingardt, J.P., Guico, R.R., Nemcek, A.A. Jr., Li, Y.P. & Chiu, S.T. (1994): Ultrasound findings following failed clinically directed thoracenteses. *J Clin Ultrasound*.22:419-426.

Wernecke, K., Galanski, M., Peters, P.E. & Hansen, J. (1987) : Pneumothorax: Evaluation by ultrasound Preliminary results. *J Thorac Imaging*.2: 76-78

Williams, S.R., Perera, P. & Gharahbaghian, L. (2014): The FAST and E-FAST in 2013: trauma ultrasonography: overview, practical techniques, controversies, and new frontiers. *Crit Care Clin.,* 30(1):119-150

Wilkerson, R.G. & Stone, M.B. (2010): Sensitivity of bedside ultrasound and supine anteroposterior chest radiographs for the identification of pneumothorax after blunt trauma. *Acad. Emerg. Med.,* 17(1):11-17

Xirouchaki, N., Kondili, E., Prinianakis, G., Malliotakis. P. & Georgopoulos, D. (2014): Impact of lung ultrasound on clinical decision making in critically ill patients. *Intensive Care Med.,* 40(1):57-65

Xirouchaki, N., Magkanas, E., Vaporidi, K., Kondili, E., Plataki, M. & Patrianakos, A. (2011): Lung ultrasound in critically ill patients: comparison with bedside chest radiography. *Intensive Care Med.,* 37(9):148-893