ERRATUM

A Description of Intraoperative Ventilator Management in Patients with Acute Lung Injury and the Use of Lung Protective Ventilation Strategies: Erratum

Regarding the article that appeared on page 75 of the July 2011 issue, the authors sincerely regret the typographical errors in the article and appreciate the readers allowing them the opportunity to clarify these discrepancies. The following corrections should be noted: The abstract and figure 1 legend should read PaO_2 rather than $PaCO_2$; also, in figure 1 and table 1, PaOC should read PaO_2, and FIO_2 is expressed as a percentage.

Reference

Blum JM, Maile M, Park PK, Morris M, Jewell E, Dechert R, Rosenberg AL: A description of intraoperative ventilator management in patients with acute lung injury and the use of lung protective ventilation strategies. ANESTHESIOLOGY 2011; 115:75–82

Utilization of Intraoperative Transthoracic Ultrasound for Diagnosis of Pneumothorax

To the Editor:

We have read with great interest the article by Ueda *et al.*[1] regarding the intraoperative use of thoracic ultrasound for detection of pneumothorax and the accompanying editorial. In the past decade, lung ultrasonography has emerged as a sensitive and specific technique for detecting pneumothorax with the added benefit of avoiding the transport of the unstable patient and less radiation exposure as compared with computed tomography of the chest. We congratulate the authors for their fine contribution.

However, it was obvious from the two described scenarios that pneumothorax was the most likely diagnosis. Although thoracic ultrasonography has a very high sensitivity and specificity for detecting pneumothorax, the results are still operator dependent. In these two cases, if the diagnosis of pneumothorax could not be confirmed by ultrasonography, would this have changed the management? In these two situations, an expedited approach may be required because of the acute respiratory distress and hemodynamic decompensation due to positive pressure ventilation, in the presence of a pneumothorax. Ideally, after all other causes for the desaturation had been ruled out and if the suspicion for pneumothorax is high, a diagnostic pleural tap should be performed looking for rush of air and, if present, will necessitate the insertion of an intercostal tube. Awaiting ultrasonography results in unstable patients might cause additional delays in management that can be deleterious, risking tension pneumothorax.

The authors mentioned that the chest radiograph is still the gold standard to confirm pneumothorax when lung sliding is not present. This statement is inaccurate. Anteroposterior chest radiography is no longer considered the gold standard for diagnosing pneumothorax in the supine patient (case 1) or the multiple trauma patient (case 2).[2] The classic sign for the diagnosis of pneumothorax on chest radiograph is the visceral pleural stripe, which is visible as a thin curvilinear opacity along the lung and is separated from the chest wall by air in the apical pleural space.[3] This sign is rarely detected in supine patients unless there is a sizable pneumothorax. Small and moderate-sized pneumothoraces can easily be missed in that position. In the supine position, air usually accumulates in the least dependent pleural spaces (which are the anteromedial and subpulmonic recesses). Furthermore, another factor influencing the site of the pneumothorax is the presence of postoperative lung collapse (due to various reasons), where air will usually have a posteromedial distribution and will not be evident on the anteroposterior chest radiograph.[4] Supine anteroposterior chest radiograph has a very poor sensitivity for the detection of pneumothorax and has been reported as low as 36% in some studies[5]; the gold standard is computed tomography of the chest, as we previously demonstrated in our review of occult pneumothorax.[3]

Rib fractures are a prominent predictor of pneumothorax after trauma, with an odds ratio of 2.65 (confidence interval 1.34–5.25, $P = 0.005$).[6] In the second case presented, the patient fell from the second story of a building and sustained multiple bilateral rib fractures. Because of the patient's high pretest probability of pneumothorax and the sudden desaturation after 5 min of mechanical ventilation, despite breathing 100% oxygen, a diagnostic pleural tap looking for air rush should be performed without any further delay for imaging.

In conclusion, we agree that chest ultrasonography can be used in stable patients when there is a suspicion of pneumothorax. However, in the severely hypoxic or hemodynamically compromised patient with a high index of suspicion of pneumothorax, a diagnostic aspiration looking for rush of air should be performed and a chest tube should be inserted. Anteroposterior chest radiographs are not sensitive to look for pneumothorax in supine or multiple trauma patients.

Hesham R. Omar, M.D., Devanand Mangar, M.D., Enrico M. Camporesi, M.D.* *Tampa General Hospital, Tampa, Florida. ecampore@health.usf.edu

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Transthoracic Ultrasound for Diagnosing Pneumothorax

To the Editor:

I read with interest the case report on intraoperative pneumothorax and transthoracic ultrasound by Ueda *et al.*[1]

Thoracic computed tomography should be regarded as the gold standard rather than chest radiography as suggested by the authors.[2–4]

The statement "because air does not reflect ultrasound" is puzzling. Ultrasound is reflected at the interface between two media with differing acoustic impedances, governed by the equation

$$R = 100(Z2 - Z1)^2/(Z2 + Z1)^2$$

where R is the percentage of ultrasound reflected and Z1 and Z2 are the acoustic impedances of the respective media.

Because the acoustic impedance of air is so low in comparison with soft tissue, ultrasound is more or less completely reflected at the air-tissue interface and cannot penetrate beyond the surface of the lung. This raises two important points: first, that by removing the air in the lung, *e.g.*, atelectasis, or replacing it with fluid, *e.g.*, consolidation, a tissular image of the lung can be created; and second, only those lesions that reach the surface of the lung can be imaged. This leads to the labeling of figure 2 in the case report where the ultrasound image labeled lung parenchyma is in fact artifact and not a tissular image of the lung parenchyma. The object labeled rib is most likely costal cartilage because normal ribs are thick enough to prevent ultrasound penetrating them and the pleural line should not be visible below. This is not the case with costal cartilage where the pleural line is easily seen below it. With high-resolution probes it is sometimes possible to delineate both the visceral and parietal pleura with a small space between the pleural gap.[5] This appears to be the case in figure 2, in which the deeper and thicker hyperechoic line labeled parietal and visceral pleura most likely represents the visceral pleura-lung interface, above which is a hypoechoic layer, the pleural gap followed by a thinner, slightly less hyperechoic line, the parietal pleura. When air is in the pleural space, the visceral pleura will not be visible through it and the hyperechoic line represents the parietal pleura-air interface.

Andrew Verniquet, M.D., Central Health-James Paton Memorial Hospital, Gander, Newfoundland, Canada. andrewverniquet@hotmail.com

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In Reply:

Thank you for your interest in our case report.[1] The following are replies to Dr. Omar *et al.* and to Dr. Verniquet.

Dr. Omar *et al.* offer several important considerations regarding occult pneumothorax in trauma patients. However, our operating room patient population differs because most of these cases are elective operations. In case 1 (elective Nissen fundoplication), the etiology of pneumothorax was surgical entry into the pleural space causing lung collapse, not tension pneumothorax. A diagnostic pleural tap may not have yielded a rush of air and may have failed as a test for pneumothorax. Other circumstances (such as mucous plug) can cause low oximeter saturation, high airway pressures, and decreased breath sounds that resemble pneumothorax. Here, an unnecessary pleural tap could potentially make circumstances worse. If the lung-sliding sign was appreciated, the diagnostic tap would have been avoided and other differential diagnoses could be advanced. A key advantage of ultrasound is its ability to noninvasively contribute to the diagnosis.