The Canadian Institute for Health Information and the Canadian Patient Safety Institute have collaborated on a body of work to address gaps in measuring harm and to support patient safety improvement efforts in Canadian hospitals.

The Hospital Harm Improvement Resource was developed by the Canadian Patient Safety Institute to complement the Hospital Harm measure developed by the Canadian Institute for Health Information. It links measurement and improvement by providing evidence-informed resources that will support patient safety improvement efforts.

The Canadian Patient Safety Institute acknowledges and appreciates the key contributions of Dr. Denny Laporta, MD, FRCPC CSPQ for the review and approval of this Improvement Resource.
**DISCHARGE ABSTRACT DATABASE (DAD) CODES INCLUDED IN THIS CLINICAL CATEGORY:**

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<td><strong>Concept</strong></td>
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<td>Pneumothorax associated with a medical or surgical procedure.</td>
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<th><strong>Selection criteria</strong></th>
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<td>S27.2–</td>
<td>Traumatic pneumothorax</td>
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<td>T80–T88</td>
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<td>Y60–Y84</td>
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For the descriptions of external cause codes of complications of medical or surgical care (Y60–Y84), please refer to the technical notes: Hospital Harm Indicator: Appendices to Indicator Library.
HOSPITAL HARM IMPROVEMENT RESOURCE
Pneumothorax

OVERVIEW

A pneumothorax is present when there is air in the pleural space. Pneumothoraces are classified as spontaneous, which develop without preceding trauma or other obvious cause, and traumatic, which develop as a result of direct or indirect trauma to the chest. Traumatic pneumothoraces can be either iatrogenic or non-iatrogenic. Iatrogenic pneumothoraces (IP) occur as a result of certain diagnostic or therapeutic procedures and constitute the current indicator (Light RW, 2016).

A tension pneumothorax is present when the air accumulates in the pleural space to a point where the increasing pressure in the pleural space impedes normal cardiovascular function. Tension pneumothorax can occur with any of the types of pneumothorax but occur more commonly – although not exclusively – to patients receiving positive pressure ventilation or CPR. It can lead – often quite suddenly – to life-threatening hypotension and shock, making it a medical emergency (Light RW, 2016).

IMPLICATIONS

Iatrogenic pneumothoraces is a potentially life-threatening complication seen in three per cent of ICU patients (Chen, 2002; Anzueto, 2004; De Lassence, 2006). It has been associated with an increase in ICU and hospital length of stay and resource utilization (Amato, 1998; Anzueto, 2004; De Lassence, 2006; Zhan, 2006) as well as an increase in the risk of death (Gattinoni 1994, Schnapp 1995, Esteban 2002). Despite doubt cast by a retrospective review (Weg, 1998), this increase was recently quantified as twice that of ICU patients without iatrogenic pneumothorax and similar to the risk of death associated with ventilator-related barotrauma or post-procedural pneumothorax (De Lassence, 2006). In addition to tension pneumothorax, systemic air embolism is a rarer but potentially lethal complication of ventilator-related pneumothorax (Azad, 2011; Ibrahim, 1999).

IP is largely preventable (De Lassence, 2006). In the ICU setting, the currently low three per cent incidence of IP in ICU patients was around eight per cent in the 1980s (De Lassence, 2006). This decrease is believed to be due to improved equipment, techniques and safer practices both for mechanical ventilation- and procedure-related pneumothorax (Celik, 2009):

- The significant decrease in pneumothorax related to mechanical ventilation over the last decades coincides with the implementation of improved “lung-protective” ventilation strategies (The ARDS Network, 2000; Miller, 2008). However, recent case series demonstrate no relationship between the incidence of barotrauma and ventilatory settings (Weg, 1998; Briel, 2010; Hsu, 2014). It may be that more factors were involved in this decrease than simply protective lung strategies, such as improved ventilators, overall ventilator care and treatment of the underlying disease processes. One example is the reduction of pneumothorax in ventilated patients with ARDS when administered neuromuscular blocking agents in the first two days of ventilation (Papazian, 2010).
The incidence of procedure-related pneumothorax has also been reduced by improved equipment (e.g. ultrasound), and education and training; these improvements have equally been noted in the non-ICU and pediatric settings (Duncan, 2009; Gordon, 2010; Havelock, 2010; Lenchus, 2010; Cavanna, 2010; Troianos, 2012).

**GOAL**

To prevent iatrogenic pneumothorax in hospitalized adult patients by implementing best practices for risk reduction.

**PROCEDURES ASSOCIATED WITH IATROGENIC PNEUMOTHORAX**

- **Dry needling** (Health Quality Council of Alberta, 2014): this term refers to interventional techniques (diagnostic or therapeutic) that use a solid filament needle to puncture the skin. A non-exhaustive list pertaining to iatrogenic pneumothorax includes: central venous catheterization (subclavian or internal jugular), thoracentesis (greater if indication is therapeutic vs diagnostic) (Gordon, 2010), transthoracic needle aspiration and percutaneous biopsy of the lung (Cox, 1999; Choi, 2004), pleura or liver, radiofrequency ablation of lung tumors, intercostal nerve block, acupuncture, and brachial plexus block (supra- or infraclavicular approaches).

- **Airway-related:** endotracheal tube insertion (intubation) or misplacement (neonates), inadequate clearance of trapped secretions, positive airway pressure devices (Carron, 2007; Chebel, 2010; Hegde, 2013; Milési, 2014) including mechanical ventilation, transbronchial lung biopsy, inadvertent endobronchial placement of small nasogastric/feeding tubes, bronchoscopy (rigid, fiberoptic (diagnostic or interventional) – more frequent in children.

- **Surgical:** tracheostomy, thoracotomy, mediastinoscopy, cardiac surgery, insertion/revision/replacement/removal of cardiac pacemaker or cardioverter/defibrillator, breast augmentation, rarely: abdominal cavity operations.

- **Other:** cardiopulmonary resuscitation (CPR).

In these series (most enumerate patient risk factors, see below), central venous catheterization, thoracentesis and mechanical ventilation are the most commonly reported procedures in adults and Pediatric case series (Johnson, 2010). For central venous insertion and thoracentesis, additional risk factors are the need to do two to three, or more needle passes and staff inexperience (Bailey, 2000; Molgaard, 2004; Gordon, 2010). Risk factors have also been described with specific procedures (e.g. transthoracic needle aspiration or biopsy (Haynes, 2010)).

§ Anzueto, 2004; De Lassence, 2006; Zhan, 2006; Celik, 2009; Loiselle, 2013; Light, 2016

*April 2016*
In most healthcare institutions, healthcare professionals are authorized to practice these interventions by the institution’s Medical Director based on professional accreditation and clinical competency.

**PATIENT RISK FACTORS**

Patient factors that increase the risk of pneumothorax in the setting of an intervention include:

- Age
- Low body weight*
- Poor healing ability (chronic corticosteroid use, malnutrition)
- Severity of acute illness*
- Acute or chronic pulmonary≠ or pleural∞ disease
- Agitation
- AIDS*

**IMPORTANCE TO PATIENTS AND FAMILIES**

A pneumothorax (a term for collapsed lung) occurs when air leaks into the space between a patient’s lung and chest wall, creating pressure against the lung. Depending on how much air has leaked in, the patient’s lung may only be partially collapsed or it may collapse completely. The greater the pneumothorax, the more it will interfere with normal breathing and may even become life-threatening. The occurrence of a pneumothorax during hospitalization is likely to prolong hospital stay.

**Patient Story**

**A Case of Iatrogenic Pneumothorax**

Ms. I. Ava Numeau, a 72-year old woman, underwent insertion of a central venous catheter via a subclavian approach in preparation for a right hemicolectomy. Now, she’s restless and complains of shortness of breath and pleuritic chest pain. You take her vital signs: blood pressure 175/95, heart rate 115, respirations 28 and room air SpO2 89 per cent. On examination, she appears in mild-moderate respiratory distress. Over the left hemi thorax there is hyper-resonance to percussion and diminished air entry to auscultation.

Ms. Numeau was admitted the previous day for resection of a cecal adenocarcinoma, which caused significant weight loss from symptomatic recurrent intermittent incomplete bowel

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* Noted for ICU patients of all ages (De Lassence, 2006)
≠ Bronchopulmonary dysplasia, acute bronchiolitis, COPD, Adult or neonatal Respiratory Distress Syndrome, cardiogenic pulmonary edema, pneumonia, primary lung cancer (Anzueto, 2004)
∞ Malignant and parapneumonic pleural effusion, empyema (Nyman, 2008)
obstruction. Her past medical history includes hypertension controlled with medication and rheumatoid arthritis for which she is on chronic corticosteroids. Her preadmission examination was unremarkable except for integumentary signs of chronic steroid use, early muscle wasting, and mild abdominal distension. After unsuccessful attempts at obtaining peripheral venous access and inability to insert an internal jugular venous catheter due to limited cervical spine and shoulder mobility, the physician inserted a central venous catheter via the left subclavian vein.

Ms. Numeau’s history reveals several risk factors for pneumothorax and the bedside assessment is suggestive of an iatrogenic pneumothorax.

The event could have been prevented by the use of bedside ultrasound-guided insertion of the internal jugular vein, which may have required only minimal neck/shoulder positioning. In addition, a Trendelenburg positioning would have increased the size of the great thoracic veins thus facilitating central venous insertion/cannulation. Finally, a peripherally-inserted central catheter (PICC) could also have been entertained, depending on the skillset of the medical provider.

Ms. Numeau’s nurse provided her with 100 per cent oxygen while monitoring her vital signs. A stat portable chest X-ray was done, confirming the diagnosis and the rapid response team prepared to insert a chest tube with a 14-gauge I.V. catheter at the bedside if the patient developed signs of tension pneumothorax. The patient received appropriate procedural sedation and analgesia. Within minutes of chest tube insertion, her vital signs normalized and her chest pain and dyspnea resolved. Repeat chest X-ray confirmed proper positioning of the chest tube and resolution of the pneumothorax.

**Evidence-Informed Practices**

Recommendations for the prevention of iatrogenic Pneumothorax:

1. **Identify Patients at Risk**
   - Develop a process to address common IP risk factors identified in the literature (De Lassence, 2006). For example, an Iatrogenic Pneumothorax (IP) Risk Score (De Lassence, 2006) which identifies ICU patients at high risk of IP, could be applied to improve the outcomes of such patients by adapting peri-procedural structure and process elements to decrease the risk of this complication. If, for instance, the management of a patient requiring central vein insertion is individualized such that: a more careful risk–benefit estimation of the procedure is made, a pre-procedure low CVP is corrected with volume repletion in order to better visualize the central vein by ultrasound, patient positioning is optimized (e.g. Trendelenburg position etc.), a physician more experienced in central line insertion is asked to supervise or perform the procedure, and/or the procedure is discontinued after a predetermined number of failed attempts. In addition, this risk score could be useful for comparing the IP rate across ICUs according to a specific level of risk.
2. Follow Safe Insertion Techniques during Pleural Procedures

- Standardize procedures and position techniques during pleural procedures, such as thoracentesis and chest tube insertion (Wrightson, 2010; Duncan, 2009; Mayo, 2009; Barnes, 2005). For example, improving knowledge to decrease/avoid pneumothorax in specific clinical conditions, e.g. mechanical ventilation/ARDS (Amato, 1998; Boussarsar, 2002; Miller, 2008; O’Boyle, 2014) and proning (Kopterides, 2009), asthma (Brenner, 2009), maxillofacial surgery (Chebel, 2010), high-flow oxygen delivery (Hegde, 2013; Milési, 2014), long-term ventilation (Vianello, 2004), percutaneous transthoracic needle aspiration and lung biopsy (Malone, 2013; Min, 2013; Tran, 2014; Wang, 2009; Zaetta, 2010). Further, appreciation of the established value of ultrasound in the prevention (Diacon, 2003; Gordon, 2010; Haynes, 2010; Havelock, 2010; Troianos, 2012) and diagnosis (Haynes, 2010; Volpicelli, 2012; Kumar, 2015) of IP will assist in its proactive and timely use in this context.

3. Physician Training


4. Standardize Practices

- Develop and standardize practices for site identification, marking, and procedural practice (Wrightson, 2010; Duncan, 2009). For example, instill a culture that proactively seeks early diagnosis of iatrogenic pneumothorax in high-risk patients to avoid poor outcomes (see above), preferably by ultrasound, or other chest imaging as appropriate. (1-4: AHRQ Quality Indicators Toolkit, 2014).

5. Conduct Clinical and System Reviews (see details below)

- Given the broad range of potential causes of iatrogenic pneumothorax, in addition to recommendations 1-4, we recommend conducting clinical and system reviews to identify latent causes and determine appropriate recommendations.

- If your review reveals that your cases of pneumothorax are linked to specific processes or procedures, the Agency for Healthcare Research and Quality (AHRQ) (AHRQ Quality Indicators Toolkit 2014) and National Institute for Health and Care Excellence (NICE) guidelines for Interventional Procedures (NICE 2015), respectively, may offer some assistance.

Clinical and System Reviews

Occurrences of harm are often complex with many contributing factors. Organizations need to:

1. Measure and monitor the types and frequency of these occurrences.

2. Use appropriate analytical methods to understand the contributing factors.
3. Identify and implement solutions or interventions that are designed to prevent recurrence and reduce the risk of harm.

4. Have mechanisms in place to mitigate consequences of harm when it occurs.

As a means to develop a more in-depth understanding of the care delivered to patients, chart audits, incident analyses and/or prospective analyses can be helpful in identifying quality improvement opportunities. Links to key resources for analysis methods are included in the section Resources for Conducting Incident and/or Prospective Analyses.

Chart audits are recommended as a means to develop a more in-depth understanding of the care delivered to patients identified in the Hospital Harm measure. Chart audits help identify quality improvement opportunities.

Useful resources for conducting clinical and system reviews:

- Chart Audit Review Process (see Introduction to the Improvement Resource)
- Canadian Incident Analysis Framework
- CPSI Patient Safety and Incident Management Toolkit
- Institute for the Safe Medication Practices Canada Canadian Failure Mode and Effects Analysis Framework
- Institute for Healthcare Improvement Failure Mode and Effects Analysis Tool

MEASURES

Vital to quality improvement is measurement, and this applies specifically to implementation of interventions. The chosen measures will help to determine whether an impact is being made (primary outcome), whether the intervention is actually being carried out (process measures), and whether any unintended consequences ensue (balancing measures).

Below are some recommended measures to use, as appropriate, to track your progress. In selecting your measures, consider the following:

- Whenever possible, use measures you are already collecting for other programs.
- Evaluate your choice of measures in terms of the usefulness of the final results and the resources required to obtain them; try to maximize the former while minimizing the latter.
- Try to include both process and outcome measures in your measurement scheme.
- You may use different measures or modify the measures described below to make them more appropriate and/or useful to your particular setting. However, be aware that modifying measures may limit the comparability of your results to others.
- Posting your measure results within your hospital is a great way to keep your teams motivated and aware of progress. Try to include measures that your team will find meaningful and exciting (IHI, 2011).
Pneumothorax

For more information on measuring for improvement, contact the Canadian Patient Safety Institute Central Measurement Team at measurement@cpsi-icsp.ca

**Outcome Measures**

- Incidence of Iatrogenic Pneumothorax.
- Percentage of Patients with Pneumothorax Developing Tension Pneumothorax.

**Process Improvement Measures**

- Percentage of ICU Patients Undergoing Risk Assessment for Pneumothorax.
- Percentage of Non-Emergent Patients Undergoing a Central Line Insertion and/or Thoracentesis with Completed Risk Assessment for Pneumothorax.
- Percentage of High Risk Patients With an Individualized Risk Reduction Plan Implemented (Example: An agitated patient will require some form of procedural sedation for central line insertion).
- Percentage of Providers Performing Procedures Associated With Pneumothorax Having Completed Appropriate Training.
- Percentage of High Risk Patients Undergoing Routine Post Procedural Monitoring for Pneumothorax (Example: post-procedure ultrasound surveillance of chest wall after difficult CVAD insertion in a patient mechanically ventilated for ARDS on PEEP of 15cmH20).

**STANDARDS AND REQUIRED ORGANIZATIONAL PRACTICES**

Accreditation Canada does not have any Standards or Required Organizational Practices that are directly related to pneumothorax.

**GLOBAL PATIENT SAFETY ALERTS**

Global Patient Safety Alerts is a web-based resource featuring a comprehensive collection of patient safety alerts, advisories and recommendations for healthcare providers and organizations. Learning from the experience of other organizations can accelerate improvement.

Recommended search terms:

- Pneumothorax
- Iatrogenic pneumothorax

**SUCCESS STORIES**

We are looking for an improvement success story related to iatrogenic pneumothorax. If you have one please share it with the Canadian Patient Safety Institute at info@cpsi-icsp.ca.

*April 2016*
REFERENCES


**HOSPITAL HARM IMPROVEMENT RESOURCE**

**Pneumothorax**


Miller MP, Sagy M. Pressure characteristics of mechanical ventilation and incidence of pneumothorax before and after the implementation of protective lung strategies in the management of pediatric patients with severe ARDS. *Chest.* 2008; 134 (5): 969-973. doi: 10.1378/chest.08-0743.

April 2016


